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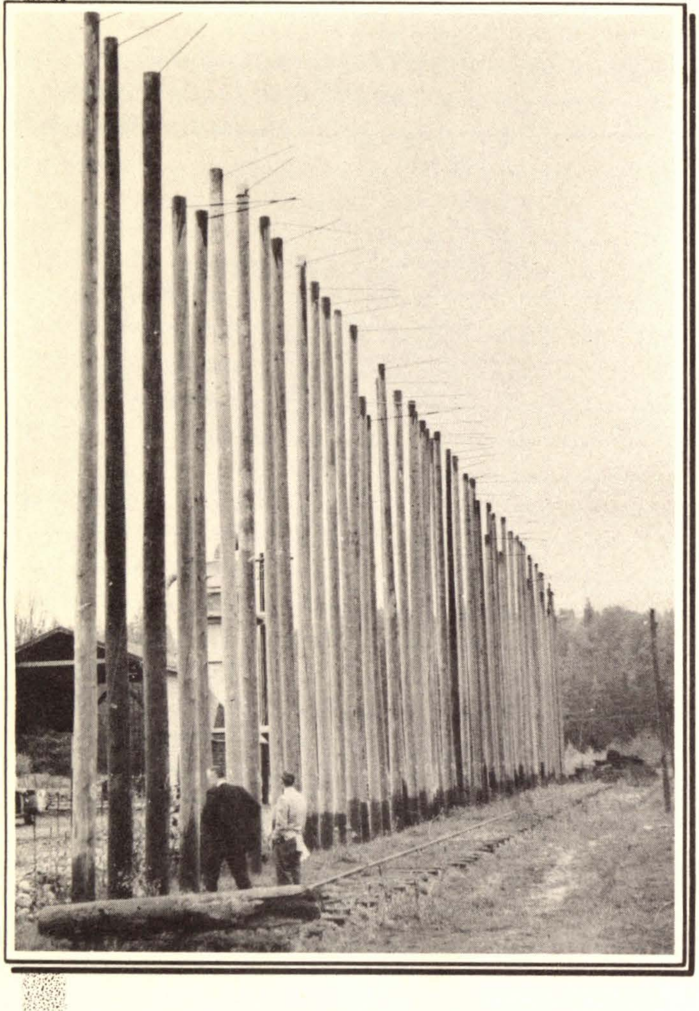
HIGHLIGHTS IN RESEARCH



ANNUAL REPORT - 1959

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
OGDEN, UTAH

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Cover Photo: Experimental study of spiral grain and twist in larch transmission poles, Libby, Montana.

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INTRODUCTION

LOOKING AHEAD IN FORESTRY

In conjunction with our review of accomplishments in research during the past year at the Intermountain Station for purposes of this Annual Report, we took the opportunity to appraise generally the progress made in forestry over the past 60 years, and to assess its future. Fruits of this review will show up in the years ahead in the form of problem delineation, problem analysis, and research programs. We are certain that research has played an important role in progress to date and that it will be essential if forestry is to maintain its rightful place in the economy. Since forestry was launched in the Intermountain and Northern Rocky Mountain regions more than a half century ago, important progress in all phases of forest and rangeland management and protection has been made. Through trial and error, experience and research, forestry has traveled along--slowly at times--the road of conservation through use.

On the basis of the record, and the experience and knowledge we have gained, we can see in general outline the picture of forestry in the future, and it looks good. The West, as does America as a whole, faces a tremendous population growth, and we are sure that the products and services of the Nation's forests and ranges will be in great demand. They will play an increasingly important role in the economic, social, and spiritual growth of the country. They will be essential to that growth and will not be made obsolete by an atomic and chemical age.

The uses to which wood will be put are limited only by the scope of our ingenuity and ability to juggle the molecules of cellulose. We will grow better wood and grow it faster by employing scientifically based cultural and protection practices. During the next centennial trees improved through breeding and selection will be in production.

Recreational use of forest lands will increase beyond the imaginations of most of us. The uses of the forests, the streams, the lakes, and the mountains to satisfy the esthetic and spiritual needs of men have increased manyfold during the past 50 years, and these needs will increase in geometric proportions during the next half century. This intensified demand calls for real leadership and a dynamic program of research to determine the recreation desires and needs of people, the capacity of wild land areas to supply these needs without destruction of their recreational appeal, the management of recreational areas to permit sustained use, and how to integrate recreation with other uses.

Range use reached the saturation point early in the history of western grazing. But the demand for forage, for both livestock and game, has steadily increased over the years. Although many adjustments in the numbers of animals grazed are yet to be made, rehabilitation of deteriorated rangelands through reseeding and improved management practices gives fair promise of increased use in the future. Grazing of livestock and big game is the only means of harvesting the valuable forage crops that large areas of lands in the West can grow. Future plans must call for reaping this harvest on a sustained yield basis.

Water, probably the most important product of forest lands, has become increasingly important and will be a limiting factor in the West's future progress. Our rapidly growing population, with its need for more and more food, and the phenomenal industrial growth are calling for more and better quality water. The multimillion dollar programs and plans for the development of rivers in our region especially interest us now, and they illustrate the extent to which the public has gone and must go in the development of its water supply. But dams alone will not do the job of water conservation. The forests and rangelands on which the waters originate must be allowed to function to regulate streamflow and control sediment production.

Probably the most significant phase of the progress made in the fields of timber, range, wildlife, and recreation--in short, multiple use--during the past two decades is the growing understanding that all these uses rest on a common and fundamental base--the relationship of the forest cover, forage plants, and use to both soil stability and the hydrologic cycle. This in turn shows us the need for a systematic integration of all our resource management plans. Such an integration is encompassed in the whole broad concept of "watershed management."

Watershed management has for its objective the maintenance of both the productive and the hydrologic, or water-regulating, functions of the land. It seeks to obtain the greatest possible quantity of wood, of forage for livestock and game, and at the same time make certain that water is yielded with the greatest possible regularity and with the least possible load of sediment.

These two vital functions of the land are completely interdependent, but the importance of this interdependence has been too little understood. Throughout the country during the past 300 years emphasis has been on exploitation of our watershed resources: on the immediate harvesting of timber and forage, without regard for future production. These past practices had both good and bad results. They fostered a rapid movement of population westward across the continent and made available the timber and forage that were needed for a growing nation. But this exploitation left the nation poorer in reserves of timber, forage, and wildlife, in acreages of stable soil, and in the regularity and clarity of streamflow.

The concept of conservation with use was born in the minds of foresters many years ago, but full application of it must await future developments. The principle of sustained yield will be gradually and fully practiced as it becomes more fully understood and recognized as a fundamental and vitalizing concept of conservation. Sustained yield of forest and range products, including recreation, combined with watershed protection, will become an accepted goal in future forestry practice.

The progress in forestry during the next 50 years, as we envision it, is predicated upon certain fundamental conditions. It will require enlightened public attitude, and more and better trained foresters. It is especially contingent upon the acquisition of knowledge through research. Our experience tells us that education and research are basic. Research programs must be enlarged and strengthened. The general goals of forestry have become clear, but many methods and procedures, principles, and concepts must be worked out scientifically before these goals can be reached.

The foundation for the practice of forestry is strong and designed to support the structure which will be built upon it. Through coordinated effort of public and private forestry agencies, users of the forest and rangelands, our schools, and the general public, this vision of the forestry of the future will become a reality. Maximum sustained yield of forest products and services is essential to the strength of the United States, at home and abroad, and to a rich and satisfying life for its people.

FOREST MANAGEMENT RESEARCH

The business of timber cutting and extraction, of getting forests started with the most desirable species in acceptable numbers and maintaining a reasonable growth rate to maturity--all at reasonable cost--is a many-sided task. When it is attempted on steep terrain where growing seasons are short and temperatures are extreme, with diseases as destructive as white pine blister rust, with insects such as the mountain pine beetle, and in many areas, highly erosible soil, problems compound themselves at an impressive rate. Our research effort in forest management at Intermountain Station continues to be directed towards solving the highest priority problems in the white pine, ponderosa pine, and larch--Douglas-fir types, with minor emphasis on lodgepole pine and Engelmann spruce. In 1959 we made substantial progress towards solving problems in these types.

FOREST GENETICS AND PLANTING

Heritability of Blister Rust Resistance and Height Growth in Western White Pine

Heritability basically is that portion of the total variations in some attributes of an organism that can be attributed to genetic differences. Heritability now is generally recognized by plant breeders as a useful index of the efficacy of selection. Workers at the Northern Idaho Forest Genetics Center at Moscow, Idaho, have adapted formulae of plant breeding heritability to the making of narrow-sense heritability estimates for sexual forest tree progenies. They have shown that blister rust resistance in western white pine is highly heritable and that height growth in this species is heritable to a useful degree.

These heritability indices measure the degree of genetic control of variation in these characters among first generation seedlings. First we must know the actual gain in resistance or height that will accompany selection of the best F_1 progenies. Then these heritabilities can be used to predict future gains in each successive generation of selection and breeding. It now appears likely that we shall make relatively rapid gains in developing rust resistance--about 20 percent per generation starting from a platform of 30-percent-resistant F_1 materials. In height growth, gains will be slower but probably no less significant. If, for instance, we can select F_1 seedlings now growing 50 percent faster than average and maintaining that advantage, then progress would be estimated at about 7.5 percent per generation. Essentially, this would mean cutting 7 or 8 years from a 100-year rotation.

Cathedral Peak Seed Production Area

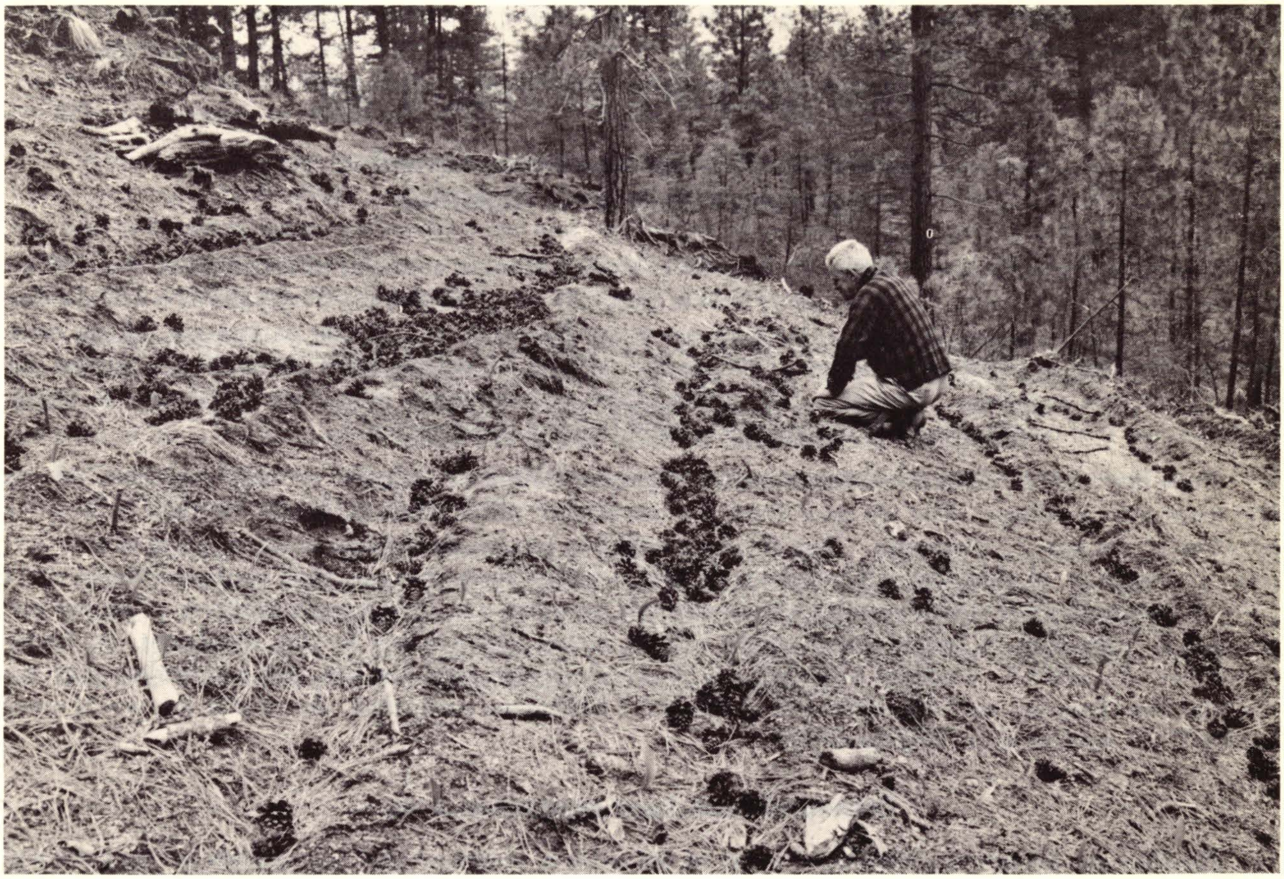
Foresters are becoming increasingly aware of the value of abundant seed from stands having good vigor and quality. Seed production areas devoted primarily to producing large quantities of seed from a known source are being established in many forested regions of the United States. We helped to establish, in cooperation with Region 1 of the Forest Service, a western white pine seed production area near Cathedral Peak in the Coeur d'Alene National Forest. In October 1959 two 3-acre blocks in a 40-year-old pine stand on a relatively level site were selected. Half the stand was thinned to an approximate 20- x 20-foot spacing, and the remainder to a 30- x 30-foot spacing.

In the spring of 1960 we shall make cone and flower counts on randomly chosen sample trees. We shall apply several types and levels of fertilizers to determine the best combination for stimulating flower production. Chemical soil analyses already performed will serve as a guide to the amount and kind of fertilizer applied. After the initial experimental stage, the fertilizing, cultivating, spraying, and cone collecting operations will be mechanized as much as possible. In addition to its primary objective of producing quantities of seed, the Cathedral Peak area will serve as a pilot scale model for other seed production areas that are now planned.

SILVICULTURE

Ponderosa Pine Regeneration on Scarified Group Clear Cuttings

Last year we reported starting a test of scarifying as a method for site preparation to aid natural regeneration of ponderosa pine in central Idaho. Thirty-one small clear-cut openings on the Boise Basin Experimental Forest were thoroughly scarified prior to seedfall from a bumper cone crop in 1958. Satisfactory coverage of these areas by seed was confirmed by using seed traps. In 1959 we began measuring germination, mortality, and survival of seedlings. All these measurements revealed varied patterns. Later measurements will determine the conclusions that can be drawn from this study.



Scarifying along contours, the cat left furrows in the mineral soil in which cones were trapped and released their seed. Fallen pine needles also collected in these furrows and served as mulch.

Germination started as early as May 1 on warm southern exposures, reached its peak about June 1, and continued sporadically through July. Germination started about a month later on north-facing slopes and reached its peak about the middle of June. Mortality started about a week after the earliest germination and continued through September.

Initial germination, though variable, was generally high. In June the 31 scarified openings contained from 1,500 to 300,000 seedlings per acre. In most openings the number of germinates varied directly with the number of seeds received. Seed-eating rodents consumed large numbers of seeds--how many, we can only guess. Seedlings were not evenly distributed, but were largely concentrated in the contour furrows created by the scarifying tractor.

Initial emergence of seedlings on mineral soil in the spring was heavy.

Numerous agents of mortality killed seedlings throughout the first summer. The most important causes included damping-off fungi, rodents and birds, insolation, drought, soil washing from heavy rains, and hail. Mortality varied greatly between openings; some sites adequately stocked in June were practically void of seedlings in October, while other sites lost relatively few. One obvious difference observed was between north and south aspects. Losses from insolation and drought were many times greater on south aspects. Stocking at the end of the year varied even more than in the spring because of the varied mortality losses. At the end of the first growing season the numbers of surviving seedlings ranged from 50 to 206,000 per acre.

Surface temperatures of mineral soil on scarified areas representing the four cardinal aspects were measured at 30-minute intervals from 10 a.m. to 4 p.m. on typical summer days. The wide variations in temperature between aspects, duration of high temperatures, and the extremes, helped explain the nature of microclimatic conditions under which ponderosa pine seedlings grow.

Results from this study will provide guides to natural regeneration in the ponderosa pine forests of central Idaho. Measurements of mortality will continue through at least one more growing season and will help define the areas in which pine regeneration is relatively easy or difficult. More important, they will help determine management measures and tools that will aid regeneration on the more difficult sites.

Bulldozer Thinning of Lodgepole Pine

Overcoming depressed growth rates is a problem in overstocked lodgepole pine stands. Mechanized methods of thinning offer possibilities for reducing costs. A few years ago we cooperated with the Lolo National Forest in Montana in a study of strip-thinning to several intensities with a bulldozer in a 30-year-old, even-aged lodgepole pine stand. This study provided an opportunity to compare the relative growth of trees in the reserve strips. Reactions to thinning by this method in terms of diameter, basal area, and height growth during the 5-year period following treatment are shown in the following table of growth of trees in reserve strips.

Reserve strip width (*Feet*)	Growth of dominant and codominant trees			Growth of intermediate and suppressed trees		
	Diameter	Basal area	Height	Diameter	Basal area	Height
	Inches	*Sq. ft.*	*Feet*	*Inches*	*Sq. ft.*	*Feet*
2	0.50	0.0152	1.86	0.21	0.0036	1.19
6	.36	.0083	1.83	.13	.0017	1.12
12	.34	.0085	3.22	.14	.0018	1.35
Control	.33	.0015	4.12	.04	.0004	.87

Diameter growth responses are nearly as great as those reported from selective thinnings in lodgepole pine in Colorado and Oregon. Depression of height growth with increased release is not unusual but is contrary to results from most selective thinnings.

Strip-thinning with a bulldozer not only appears to benefit tree growth, but it should surely improve accessibility to overstocked stands and thereby reduce the cost of future stand improvement work. However, these favorable results must be balanced against cost in planning any individual thinning projects.

Western Larch Pole Management

Transmission pole producers in northern Rocky Mountain country seek western larch especially for their larger sized poles. Larch transmission poles have high preference because of their superior strength and large size. However, some larch has characteristics that detract from its use for poles, but we believe these can be altered by management. Some larch trees have thin sapwood; in these it is difficult to obtain the necessary penetration and retention of preservative. Other trees have spiral grain, common in most pole species, that may cause twisting of the pole in service.

Workers in forest management and forest utilization research at our Missoula research center began studies on this problem in 1959 to include three phases:

1. A survey to investigate the effect of tree and site factors on form, spirality, sapwood depth, and rate of growth and strength of wood.

2. Study of the effects of thinning and other stand improvement practices on growth, form, sapwood depth, and spirality.

3. Cutting tests, yet to be installed, to test preliminary guides developed from the above two phases of the study.

The field work for phase 1, a cooperative undertaking between Intermountain Station and the J. Neils Lumber Company (see cover photo), was more than half completed in 1959. Each tree selected in the survey constituted the sample and was also the center for 1/5-, 1/10-, and four 1-milacre plots. Trees were selected to sample a wide range of site factors. Data on external tree characteristics were collected from sample trees, and data on site factors were collected from the plots surrounding the sample trees.

Preliminary analysis of data on sapwood thickness in a thinning study in 50-year-old western larch indicates that sapwood thickness is related significantly to both the rate of growth of trees and to the stand basal area. Therefore, regulation of stand density and maintaining rapid growth of the trees tends to favor greater sapwood depth.

Partial Cutting in Western White Pine

Tests of partial cutting in the white pine type have verified vigor classification and point the way to at least partial solution of some difficult management problems. Forest managers on many northern Rocky Mountain working circles are confronted with an overabundance of mature and overmature timber. Silviculturally speaking, these stands should be harvested and the land regenerated, but, to satisfy the management requirement of a uniform flow of raw materials, many of these stands must be held for several years before regeneration cuttings can be made. In the meantime, these stands are subject to losses from beetles, wind, snow, and decay. As a result, little if any net growth is realized. How can we hold these timber stands for a future major harvest and at the same time make them pay dividends? This question has been the object of extensive studies since 1941.

One answer is light partial cutting in which each tree to be removed is selected on the basis of its vigor.* The vigor class of a tree is determined by a combination of easily recognizable external characteristics including crown class, length of live crown, tip vigor, crown density, dead branches, and foliage color. Validity of this vigor classification and the merits of vigor selection cutting have been tested on 16 sample plots totalling 131 acres and including 5,704 tagged western white pine trees. These studies show that susceptibility to beetles, windthrow, snow damage, and other causes of mortality is highly correlated with tree vigor. In addition, the better the vigor, the greater the diameter growth. Gross growth, mortality, and net growth also are highly correlated with tree vigor. Hence, poor and fair vigor trees are poor risk and should be removed wherever possible while they are still marketable.

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*Wellner, C. A. A vigor classification for mature western white pine trees in the Inland Empire. Northern Rocky Mountain Forest and Range Expt. Sta. Research Note 110, 3 pp. 1952.

Results of this study support the long held belief that light partial cutting on the basis of tree vigor offers real opportunities to:

1. Keep a needed inventory of vigorous mature stands, and at the same time to harvest a dividend in the form of anticipated mortality and to salvage material that might otherwise be lost.

2. Improve beetle resistance of the forest.

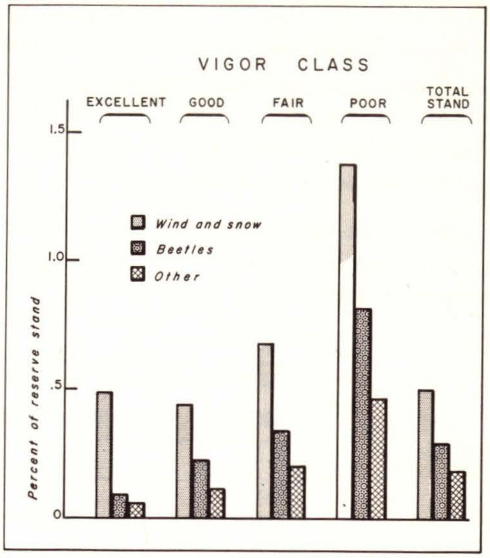
3. Increase average tree growth by reserving only trees having good diameter growth rates.

4. Open the stands by road networks to intensive management and then salvage subsequent mortality.

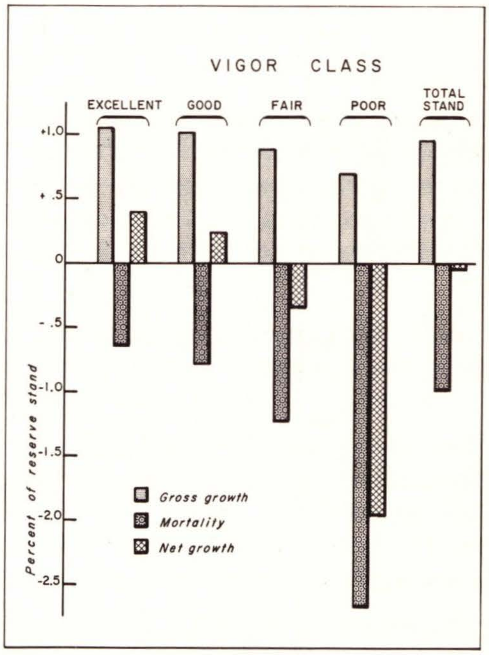
5. Aid blister rust control through suppression of ribes.

6. Hold white pine stands for future developments and decisions with respect to blister rust control--thus possibly saving additional acres for white pine production.

No cutting practice is a panacea, however; and vigor selection cutting has its hazards. Only stands having a high proportion of the better vigor classes should be partially cut. Cuttings usually should not remove more than 30 percent of the stand volume--and this should be primarily in the poor and fair vigor classes. When properly applied, partial cutting on a vigor selection basis can be valuable in the management of mature and overmature western white pine stands.



Mean periodic annual mortality of western white pine on 16 sample plots.



Mean periodic annual gross growth, mortality, and net growth of western white pine on 16 sample plots.

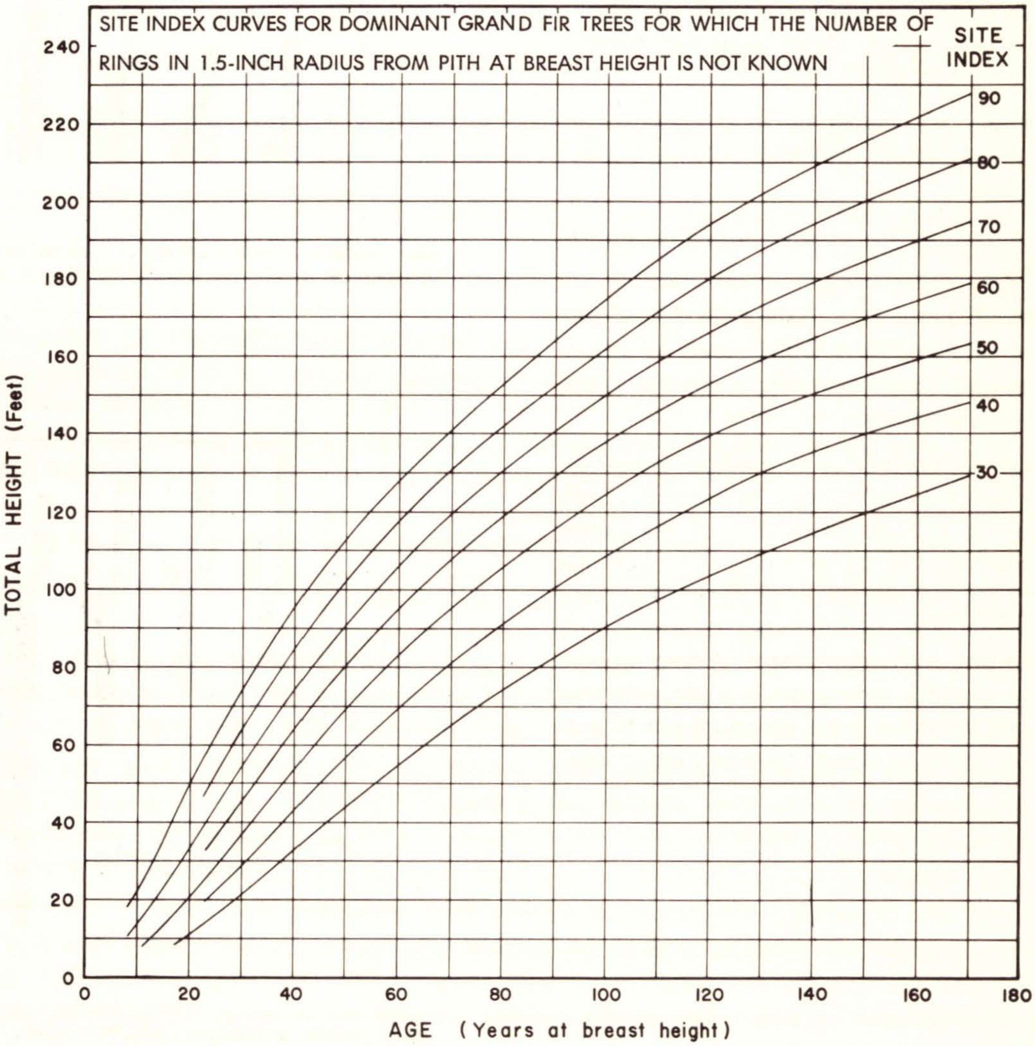
GROWTH AND YIELD

Grand Fir Site Indices

As the tempo of management of this "Cinderella" species increases in the Inland Empire, foresters' first inquiries about grand fir include questions related to site quality evaluation. To provide an answer, we analyzed stems of 66 dominant grand firs between 50 and 160 years old. The results led to the first grand fir site index curves.

These curves, based on height increment, vary in shape according to the early growth rate of the trees. Since grand fir is a tolerant species its early growth rate is determined largely by competition from neighbors in the stand. Hence, our curves are based not on the actual height-age relations of the sample trees, but rather on height increment attainable when trees reach 55 feet height. Thus, we have reduced the effect of early competition on our site estimation.

Of course our final curves give conventional site indices for height at any age. Curves have been prepared for use both where rings in the first 1.5-inch radius from the pith at breast height are known and where this information is not available.



Effects of Stocking on Growth and Yield of Lodgepole Pine

Growth and yield of lodgepole pine are correlated with density of stocking. Data from closely grouped plots in Montana on the same site in even-aged stands of varying density show strikingly uniform patterns of variation. These trends are evident in all age classes up to 120 years, the upper limit of sampling. Data from representative plot clusters on medium site in two age classes are as follows:

Trees per acre	Av. dominant d.b.h.	Av. dominant height	Av. dominant crown ratio	Av. stand d.b.h.	Basal area per acre
Number	*Inches*	*Feet*	*Percent*	*Inches*	*Sq. ft.*
		Age 40			
140	9.0	35.9	92.0	7.4	42.4
450	7.2	35.7	83.8	6.0	89.2
812	6.7	35.2	76.4	5.0	110.6
2,211	4.7	30.3	58.3	3.3	133.7
4,628	3.8	26.5	55.8	2.3	129.2
		Age 53			
468	7.9	45.5	85.0	5.4	73.6
976	6.4	46.2	70.0	4.8	124.7
2,064	5.2	39.9	67.3	3.4	129.4
4,182	4.4	36.4	61.9	2.4	133.9
6,000	3.5	33.2	54.0	2.1	147.3

The direction and magnitude of these growth reactions are providing leads for further investigation of the density variable in a study started in 1957.

Point Sampling

The precision of a cruise using "point-samples" or variable-size plots depends on many things. Using the right prism factor and accurately classifying marginal trees are two critical factors. With the cooperation of Region 1 of the Forest Service, we undertook a study to determine: (1) the sources of error in using a prism of the wrong factor; (2) the number of "point-samples" needed to achieve the same accuracy of basal area estimate as a conventional survey based on 1/5-acre plots; and (3) the most appropriate prism factors for our conditions.

Determining whether marginal trees are "in" or "out" is a frustrating part of any field survey. We found that use of a prism does not eliminate the risk of checking marginal trees. However, shortcutting this job has less effect on the accuracy of variable-plot surveys than of fixed-plot surveys.

Specifically, our study of the marginal tree problem showed three things. First, 10x prisms were less precise than 25x prisms in deciding whether marginal trees should be counted or ignored. Second, marginal trees that should not be counted were more easily determined than were trees that should be counted. Of the marginal trees in our study, 71 percent should have been counted. Third, sloping ground did not decrease the precision of use of a prism provided the procedure of correcting for slope with an abney was used.

We analyzed for the influence of timber type, age class, and stocking. Timber type had no effect on the relation between variable- and fixed-plot sampling in estimating basal area, but age class was important. Variable-plot estimates of basal area tended toward underestimation in sawtimber stands, especially when the stocking was high. This tendency was more pronounced where the 10x prism was used, especially on trees larger than 18 inches d.b.h. Conversely, the tendency was to overestimate basal area of poletimber stands (stems less than about 16 inches d.b.h.) when using the 25x prism. For the conditions of stocking and size we encountered, the 25x prism estimate of basal area was only 0.5 percent less than the measured basal area on fixed-area plots.

Comparison of the relative efficiency of variable- and fixed-plot cruises showed the superiority of "point-sampling." To achieve comparable estimates of basal area, fewer trees and fewer locations would have to be sampled with prisms:

Prism factor	*Percentage of numbers sampled by fixed plots*	
	Trees per plot	*Locations sampled*
25	42	87
10	118	49

Comparison of the efficiency of the two prism strengths showed that to achieve estimates having comparable accuracy, about twice as many locations would have to be sampled with a 25x prism as with a 10x prism. However, the plots sampled with the 25x prism would contain only 40 percent as many trees per plot or about 60 percent as many trees for the entire survey.

For general use in northern Rocky Mountain forests the 25x prism appears to be the more suitable, but for well stocked large sawtimber an even higher basal area factor may be more desirable. Where timber is small and visibility good, the 10x prism seems best suited.

FOREST DISEASE RESEARCH

Improvements in disease surveys and control measures are the ultimate objectives of new and expanded efforts in the division of Forest Disease Research. In 1959 the division began research designed to improve survey techniques and expanded research in the use of antibiotics in controlling forest diseases.

DISEASE SURVEY TECHNIQUES

Chief objectives of the studies to improve disease survey techniques are:

1. To test the efficiency of certain commonly used survey methods and intensities in the appraisal of dwarfmistletoe infection for judging the possibilities of controlling dwarfmistletoes through silvicultural and direct control practices.

2. To test the use of surveys in appraising damage to growth sustained by individual trees and stands infected by dwarfmistletoe, and to measure the spread and intensification of this parasite as young stands are thinned.

Both these studies were made possible by the cooperation of National Forest Administration.

FOREST DISEASE SURVEYS

Dwarfmistletoes

Extensive surveys of the distribution of dwarfmistletoes were concentrated in northern Idaho on the Kaniksu National Forest and the interior of the Nezperce National Forest. Our extensive surveys of dwarfmistletoe, which have continued through several years, are now nearly complete in western Montana, northern Idaho, and northeastern Washington.

Intensive sampling of dwarfmistletoe damage to determine most efficient appraisal methods.

Analysis of data from a roadside strip survey in the interior of the Nezperce National Forest shows that 35 percent of the 155 miles traversed in lodgepole pine stands contained infected trees. Dwarfmistletoe was found in western larch and Douglas-fir in the interior of this forest, but was much less serious in these species than in lodgepole pine.

Dwarfmistletoe infection on trunk of a western larch sapling. This tree will never produce merchantable lumber.

An intensive precontrol survey of dwarfmistletoe infection in a 160-acre tract was made in the Colville National Forest. This stand has an overstory of infected western larch, Douglas-fir, and lodgepole pine fire residuals which will be logged off. The understory is overstocked with western larch and also contains Douglas-fir, lodgepole pine, Engelmann spruce, and western redcedar. Infected reproduction was found on or near four-fifths of the 206 sample plot locations. However, only 30 percent of the western larch, 4 percent of the Douglas-fir, and 11 percent of the lodgepole pine trees were infected. This stand averages more than 5,000 trees per acre. Except for a few small spots of very heavy infection, enough uninfected or prunable infected trees are present to permit elimination of the parasite without excessive reduction in stocking.

The station provided technical assistance on dwarfmistletoe control operations in infected lodgepole pine in two national forests.

Needle diseases

Although most conifer species suffered severe damage from needle diseases in most parts of Region 1, larch was peculiarly unaffected in 1959 by *Hypodermella laricis*. *Meria laricis* was observed only infrequently. Lodgepole pine was severely infected with *Hypodermella concolor* especially in western Montana, northeastern Washington, and throughout Idaho. Douglas-fir was again hit in epidemic intensity by *Rhabdocline pseudotsugae*. Alpine fir, attacked by two needle fungi, *Phacidium infestans* var. *abietis* and *Botrytis cinerea,* was most noticeable among the other affected species. Several thousand acres of whitebark pine in Yellowstone Park were damaged by *Lophodermium nitens.*

Comandra rust

The comandra rust, *Cronartium comandrae*, previously reported on six national forests in Region 4, was found causing severe losses in lodgepole pine stands on the Beaverhead, Lewis and Clark, Gallatin, Deerlodge, and Custer National Forests in Region 1. Weather in 1959 favored heavy infection of the alternate host, *Comandra umbellata*, and abundant fall rains probably favored another wave of infection to pine.

ANTIBIOTIC CONTROL OF FOREST DISEASES

A pilot test of the feasibility of aerial application of the antibiotics Acti-dione, Phytoactin, and Acti-dione's derivative semicarbazone, to control white pine blister rust was carried out by Region 1 in June. Fourteen separate 10-acre blocks of sapling, pole, and mature timber in the St. Joe National Forest were sprayed. The test areas contained western white pines and many other species commonly associated with white pine. These variations in tree age and species provided us an opportunity to observe effects of these antibiotics in different rates of application on a variety of diseases.

Individual trees were selected in each block to study both the effect of the antibiotic on health of all tree species and on the diseases affecting them. Several diseases were present in sufficient intensity to provide adequate samples. They were: needle blight of western white pine, (of unknown cause), needle cast of western white pine (*Hypodermella arcuata*), western gall rust of lodgepole pine (*Peridermium harknessii*), needle cast of lodgepole pine (*Hypodermella concolor*), and needle rust of lodgepole pine (*Coleosporium solidaginis*). The latter two were sampled less intensively than the first four. Sample trees will be examined in the spring of 1960. Plans for future research will be developed according to results obtained from the 1959 treatments.

Basal application of the antibiotic Acti-dione to determine its effect on the limb rust of ponderosa pine; A, as an oil-base spray; B, in a low-volatility jelly.

These same three antibiotics in various concentrations were tried as basal trunk sprays and foliar sprays under a variety of conditions on the limb rust of ponderosa pine (*Peridermium filamentosum*), comandra blister rust of lodgepole pine (*Cronartium comandrae*), lodgepole pine rust (*Cronartium stalactiforme*), western gall rust on lodgepole pine, the yellow witches'-broom rust of subalpine fir (*Melampsorella caryophyllacearum*), dwarfmistletoe of lodgepole pine (*Arceuthobium americanum*), and the needle and twig blight of ponderosa pine (*Elytroderma deformans*). First results of these experiments will be available next field season.

CROWN DETERIORATION OF WESTERN WHITE PINE

During the past two years a complex disease of western white pine has been under study by pathologists and entomologists of this station, Dr. C. G. Shaw of Washington State University, and the Potlatch Forests, Inc. This disorder is primarily characterized by mortality of twigs and foliage progressing within the crown from the bottom upwards and on branches from the stem outwards* The affected portion of the crown thus shows a symmetrical cone-shaped pattern. Occasionally trees have died after their live crown was reduced below the level required to sustain vigor and good health. This disorder has been observed throughout the western white pine territory from the Clearwater River north to the Canadian border.

Several fungi have been found in association with death of white pine needles. Two have been identified, and their respective roles in the problem have been separated. One fungus constantly associated with symptoms of lower crown deterioration occurred on nearly all dead needles in affected portions of crowns. This fungus is similar to and has been identified tentatively as *Lecanosticta acicola*, recently reported on eastern white pine in the Southeast. This fungus was also found in northwestern Montana on planted eastern white pine showing crown symptoms similar to those observed in western white pine. More work must be done to establish the importance of this fungus and of certain aphids and a mite as agents responsible for white pine crown deterioration.

Hypodermella arcuata was found frequently on trees showing lower crown deterioration. Reported for the first time on western white pine, this fungus was found most commonly in the upper crowns of trees. Though important as a needle cast, damage is not related to the lower crown deterioration problem.

WHITE PINE BLISTER RUST MICROCLIMATE

The delicate short-lived sporidia of white pine blister rust (*Cronartium ribicola*, Fischer) form in autumn, when humidity is high. Since the rate of their fall is slight, they can be transported by very gentle air currents. Blister rust spread is a problem of small-scale dispersion of these spores from a single point source during moist periods of sufficient duration to result in spore production and pine infection.

Air Movement During Moist Periods

Equations developed in studies of air pollution, chemical warfare, and atomic energy can be applied to determine concentration of sporidia at given distances from a source. But first we must know more about wind direction and speed and thermal stability of air in mountainous terrain during moist periods. Considerable information about air movement during clear weather is available, but very little is known about air movement during the moist periods that favor spore production and pine infection.

To provide this information, we have started to study air movement and atmospheric stability during moist periods in the white pine belt of the Inland Empire. We anticipate that the information obtained will make possible a closer definition of widths of protective zones around white pine stands. Further, we may be able to explain the unusually long distance spread of the rust that occurs in some problem areas.

This year observations of air movement were made during stable summer weather and autumn rainy periods in mountainous terrain. A hot-wire anemometer and chemical smoke grenades were used to trace wind direction and velocity. An Assman psychrometer was used to determine temperature and humidity near the ground. A captive balloon capable of carrying temperature and humidity measuring instruments aloft enabled our meteorologist to determine thermal structure of the atmosphere up to 1,500 feet above ground.

This same equipment was used to follow the vertical distribution of temperature and humidity in the

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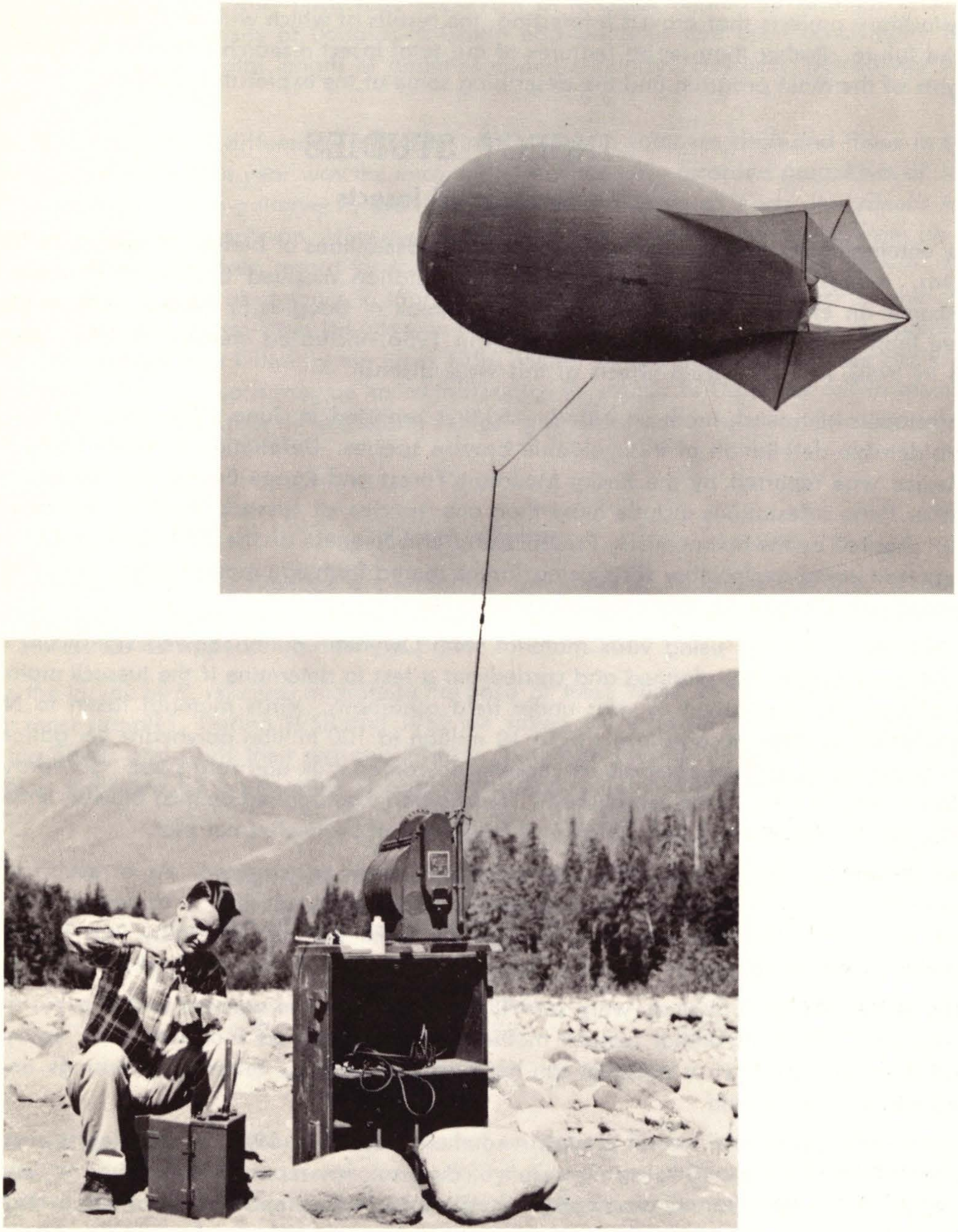
*For details see Robert E. Denton, and Charles D. Leaphart, Symptoms of abnormal crown deterioration in western white pine stands, Intermountain Forest and Range Expt. Sta. Research Note 69. 1959.

Carbon River Valley of Mount Rainier National Park during selected weather situations. Our efforts supplemented a basic study by the Department of Meteorology of the University of Washington. The objective was to develop the basic theory of slope and valley winds. As theory develops and our experience increases, we shall be able to predict how the wind blows in mountains in both clear and rainy weather. When we can make such predictions, we can determine the probable distance of spread of blister rust from known infection sources under the variety of conditions encountered in the Inland Empire.

Captive balloon equipment used in the Carbon River Valley of Mount Rainier National Park to determine thermal structure of the atmosphere.



FOREST INSECT RESEARCH

Intermountain Station's program of forest insect research is designed to serve three chief purposes: studies of several insect species of primary importance in Intermountain forests to determine factors affecting their abundance; improvement in methods of measuring populations and determining their trends; and general insect surveys to detect and evaluate significance of forest insect outbreaks from year to year. The program has an over-all objective of developing economical and effective methods of reducing insect-caused losses in forests.

The regular long term program of research was carried on as planned. During the year we conducted several exploratory projects that proved interesting, the results of which will be used to develop research programs in the future. Rather than report features of our total insect research program for 1959, we are selecting highlights of the main program and are describing some of the exploratory projects.

INSECT STUDIES

Diseases of Insects

Forest entomologists are greatly interested in the possibilities of biological control, including the effect of pathogens. Interest in this subject at Intermountain Station received additional impetus when a virus disease became an effective control factor in an outbreak of Douglas-fir tussock moth in Owyhee County, Idaho, more than a year ago. The outbreak began in 1956, increased sharply in 1957, but was virtually eliminated in 1958, primarily from effects of this virus disease.

An infestation of tussock moth on bitterbrush, first reported in June 1958 near Carson City, Nevada, caused considerable defoliation of this valuable browse species. Defoliation of white fir by a tussock moth in New Mexico was reported by the Rocky Mountain Forest and Range Experiment Station. We do not yet know whether these infestations include more than one species of tussock moth since identifications have not yet been checked by the taxonomists. Presence and effectiveness of the pathogen in the Owyhee County outbreak spurred some exploratory tests using larvae reared from egg masses collected in Idaho, New Mexico, and Nevada on Douglas-fir, white fir, and bitterbrush.

Our laboratory rearings using virus material from Owyhee County showed significant mortality in all lots from the three states. We planned and carried out a test to determine if the tussock moth on bitterbrush would be affected by application of virus under field conditions. Virus material taken to Nevada in May 1959 was applied at three dosage levels from 10 million to 100 million polyhedra per gallon at the rate of one gallon per acre using two materials as stickers--powdered milk and corn syrup. Six spray plots and two checks, each 1 acre in area, were established. The solution was applied by mist blower. Pre- and postspray counts were taken from four 15-inch twigs and from each of six bushes per plot.

Strong variations in actual populations between plots were encountered. As a result, differences in results between the dosage levels were not clear cut. In some sprayed plots it appeared that the virus was established and that it effected control ranging from 59 to 90 percent. Mortality was figured according to Abbott's formula, which allows for mortality occurring naturally in untreated check populations.

Results of this exploratory study were sufficiently encouraging to warrant further exploration in the field of insect diseases. They show that tussock moths are susceptible to inoculation by spraying their food plants, and that supplies of virus material can be increased both by laboratory rearings and by collection of diseased material in the field.

During a spruce budworm control project in southern Idaho in 1957 one biologist reported apparent heavy larval mortality suspected to be the result of disease. His report was received so late in the season that only a half-dozen dead larvae were collected. Virus material prepared from them in 1959 produced 62 percent mortality in cage tests. This find is interesting because previously there had been little evidence of effective disease organisms in spruce budworm populations.

Douglas-fir Beetle

Our studies of epidemiology of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk., continue. We are accumulating data on many factors causing changes in abundance of this beetle in stands of interior Douglas-fir. Many findings from these studies are applicable to what may be termed management control, but we constantly seek opportunities for biological control. We hope eventually to be able to predict the course of populations of this beetle with reasonable accuracy.

Geography and Host Material Affect Sampling

Population measurements have uncovered important differences related to location and condition of host. For instance, average density of Douglas-fir beetle egg galleries has been consistently less in down trees than in standing trees. Total length of galleries varied similarly. However, percentage of brood survival was greater in down trees.

We also found important differences between infestations in southern Utah and those in southern Idaho. One interesting event of the year was the encountering of the only recorded parasitism of adult *D. pseudotsugae*. Many parents in egg galleries in Utah each contained a larva of *Tomicobia tibialis* Ashm. (Pteromalidae). Also, another hymenopteron, *Mira macrocera* Schell. (Encyrtidae) was reared from an infested cull log. This is a new North American record for the species, which previously had been known only from Europe. Other differences include abundance in Idaho of the ostomid predator, *Temnochila virescens chlorodia* (Mann.), but complete absence on Utah Douglas-fir. This situation is unusual because the predator is abundant on nearby ponderosa pine killed by the Black Hills beetle, *Dendroctonus ponderosae* Hopk. Woodpeckers searching for bark beetle broods may be heard in Douglas-fir stands in Utah but not in most of southern Idaho. Recognizing these and other differences in sampling is important to future application of results of the study.

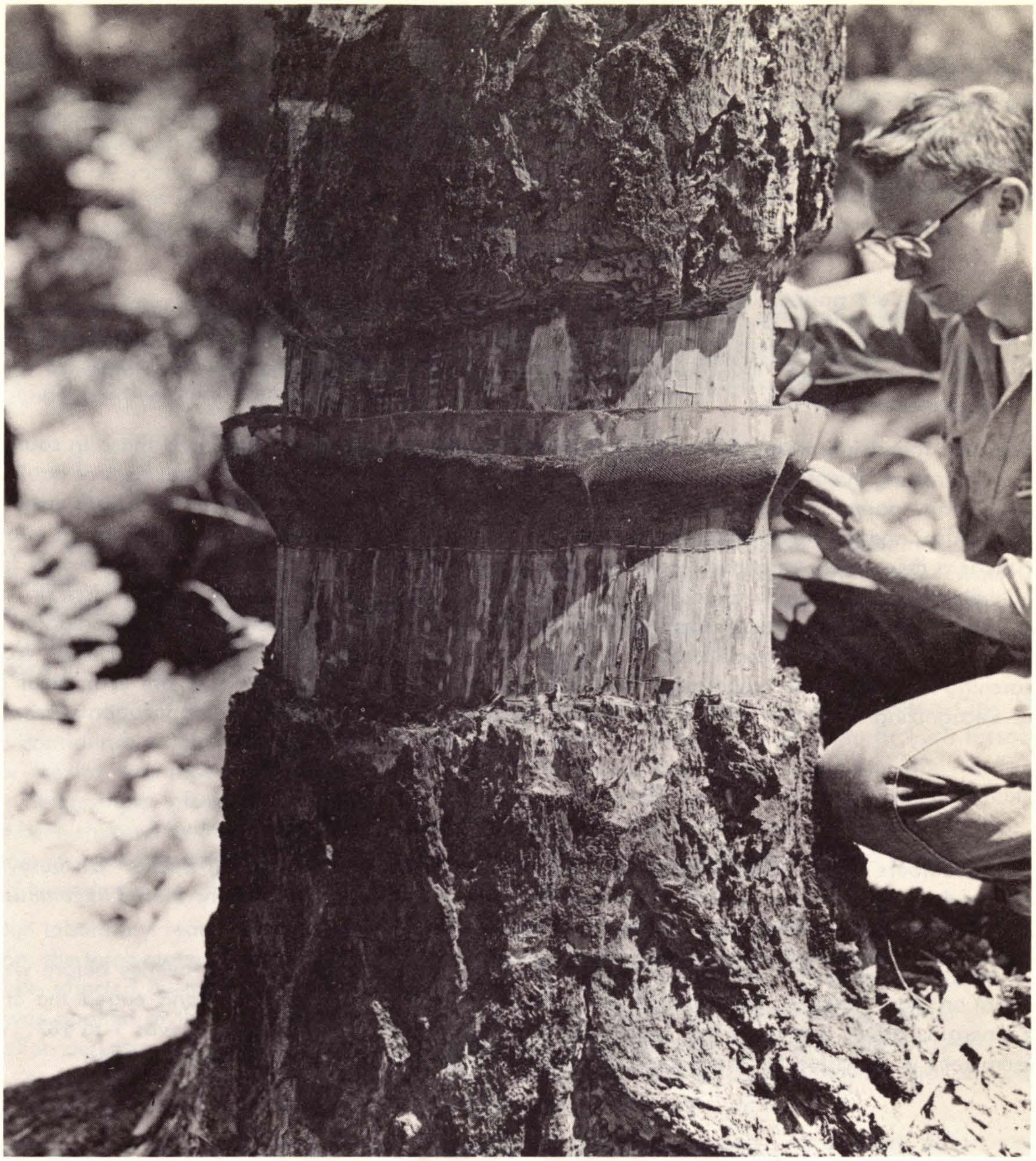
Clerid Predators

Two members of the family Cleridae are important predators of Douglas-fir beetle. Of these, the red-bellied clerid, *Enoclerus sphegeus* Fab., is many times more abundant in Douglas-fir than *Thanasimus undatulus* Say (not *undulatus*, as appears so often in print).

In Idaho the larvae of *E. sphegeus* migrate to the base of trees killed by bark beetles before we can record them on most samples. During 1958 and 1959 we felled 17 infested trees and caged the stumps to count emerging adults and study their seasonal history. Range of number of adults was 1 to 187. Variation between trees is indicated by a grouping of cages according to number of emerged cleriods:

Number of cages	*Number of cleridae*	*Percent of total*
12	85	18
4	208	43
1	187	39
17	480	100

This year we also tried to measure the number of migrating *E. sphegeus* larvae for comparison with adult emergence in order to estimate overwinter mortality. Our funnel-shaped cages installed on five standing trees caught 32 larvae. We have designed improved cages for another attempt.



Cage installed on beetle-infested tree to study migration of clerid larvae

Preventive Spraying

We tested 2-percent DDT emulsion spray to determine its effectiveness in preventing establishment of Douglas-fir beetle in fresh logs. Toxicity of DDT is low compared to that of some other insecticides, but it has a long residual life, is inexpensive (9 cents per gallon), and is highly effective in preventing infestation of live trees by other bark beetles. For test, we sprayed 11 logs at an average rate of 2.7 gallons per 100 square feet and kept an equal number of untreated logs for check. Logs varied greatly in diameter, length, and bark thickness.

We used several methods in measuring effectiveness of spray treatments. These included the usual presence- or absence-test of attack by barkbeetles and, in addition, more detailed brood examination by means of bark samples. These were taken from the shaded undersides of logs, where Douglas-fir beetle attacks were most numerous, and from the sun-exposed top of each log, where wood borers (Buprestidae and Cerambycidae) are most abundant.

Weekly counts of attacks during the first 3 weeks revealed a relatively small number in unsprayed logs but none on the sprayed logs. It appeared that the aromatic petroleum derivative in the spray concentrate exerted a repelling effect. Incidence of attack appeared to coincide with dissipation of the oil by weathering and vaporizing. Our results showed that where eventual attack was successful in sprayed logs, egg galleries were fewer in number and were shorter in length than on unsprayed logs, as shown in the following tabulation:

Factor sampled	*Treatment*		*Significance of difference*
	DDT	*Check*	
Douglas-fir beetle:			
Live brood			
Number on 6" X 12" slab	58	105	Not significant
Egg galleries			
Number on 6" X 12" slab	2	5	Significant
Number on 6" X 48" slab	7	16	Significant
Length (in.) on 6" X 12" slab	6	21	Highly significant
Length (in.) on 6" X 48" slab	23	83	Highly significant
Wood borer:			
Egg galleries			
Number on 12" X 12" slab	3	15	Significant

Live Douglas-fir beetle brood was nearly twice as abundant on untreated samples, but we could not attribute this difference to treatment alone. However, aborted galleries containing dead parents were encountered only on sprayed samples. Lack of greater effect from treatment seemed to be due to:

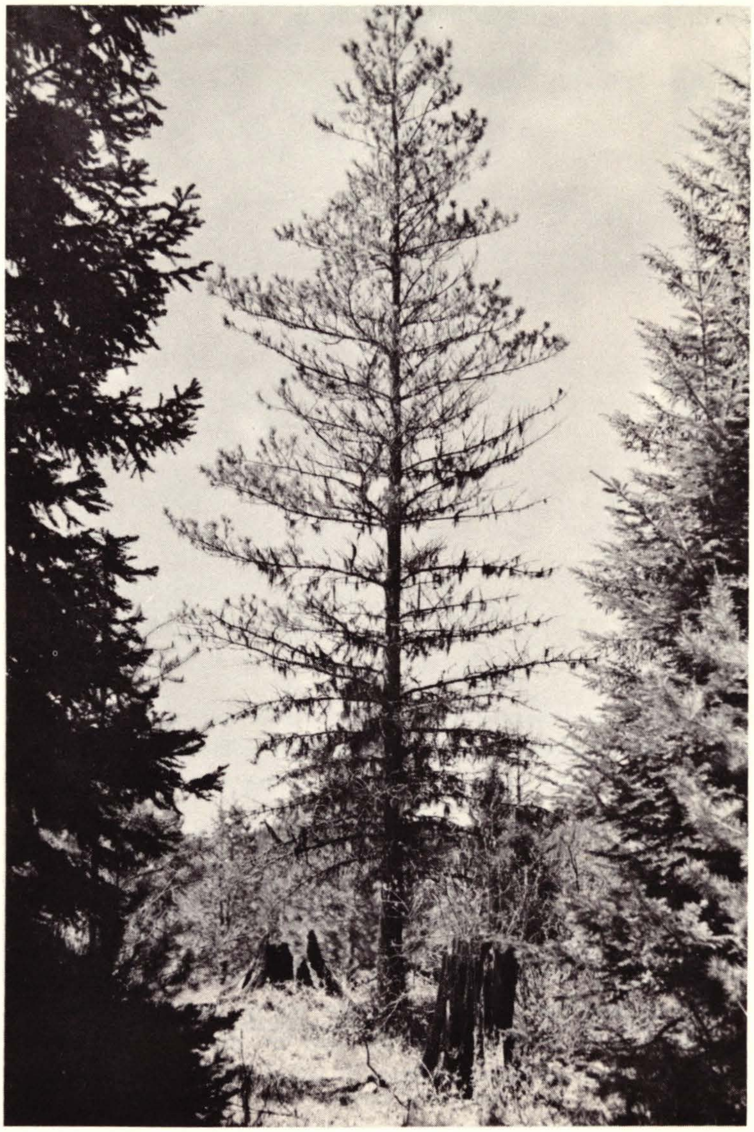
- Removal of petroleum oil, which temporarily acted as a repellent.
- Washing or weathering of the DDT.
- Uneven spray coverage on undersides of logs that could not be rolled.

Results suggest that attacks by Douglas-fir beetle in green logs might be prevented by a second application of spray after 3 weeks or possibly by using a single spray containing more oil. If further studies should validate this supposition, such sprays might be used for protecting especially valuable trees and for low cost beetle proofing of logs and windthrown trees in which broods often survive at a higher rate than in standing trees.

Pineus sp. in Western White Pine

Unexplained symptoms of crown deterioration in immature western white pine stands in the Inland Empire posed a perplexing problem this year. Instances of similar deterioration had been observed previously in local areas of northern Idaho, but the seriousness of the present situation warranted considerable attention from pathologists, entomologists, and foresters. Reconnaissance disclosed that crown deterioration prevails throughout the western white pine type in northeastern Washington, northern Idaho, and western Montana.

Obvious visual indicators of this crown deterioration are the death of 2-year-old or older foliage and the dying of branches in the lower portion of tree crowns. In spring and early summer the dying and dead needles give the crowns a striking reddish color. In advanced stages of this deterioration of the foliage is thin and sparse, and the current year's growth at the tips of the branches gives the tree crowns a ragged, tufted appearance.



This western white pine shows advanced symptoms of crown deterioration.

Although the blighted appearance of affected crowns suggests a disease problem, observations implicate a species of aphid (*Pineus* sp.) as a possible contributing factor. Aphids are commonly found on the bark along the foliated portions of twigs. They often form a ring around the base of the current year's growth shoot or fasten themselves at the extreme base of needle fascicles.

Because of a possible association between aphids and crown deterioration, we undertook preliminary observations and sampling to determine if such a relationship could be readily proved or disproved. Because the dying of branches begins at the base of the crown, we thought if an aphid were responsible there might be a difference in aphid numbers between the lower and upper crown; lack of such difference might indicate that aphids are not associated with this crown deterioration.

Sampling of five trees at each of three crown levels disclosed:

1. Aphids are found on current-year and 2-year-old growth shoots throughout the length of the tree crowns; however, aphids in the upper crown apparently are a different species from those in the lower crown.

2. Counts on a linear-inch basis showed twice as many aphids on new growth shoots in the lowest third of the crown as were in the top third; fewest aphids were in the middle third of the crown.

We have not yet determined what species of aphids are involved. The main difference between aphids in the lower and upper crown is that the immature stage of the aphid in the lower crown is scalelike in form, unlike the adult, whereas in the upper crown the nymphs are soft-bodied and fat, and closely resemble adults. Practically no scalelike form was found above the middle third of the tree crown. This suggests a possible connection between this aphid and symptoms of crown deterioration.

To explore this possibility we compared "scale-type" aphid populations and the degree of crown deterioration. We rated affected pine trees according to three intensities of deterioration: light, moderate, and heavy. Aphid populations were measured on 10 trees in each class of severity. Sampling was confined to current-year shoots in the lowest third of the crown and gave the following results:

Degree of crown deterioration	*Aphids per linear inch of 1959 growth shoot*
Light	0.4
Moderate	.3
Heavy	5.5

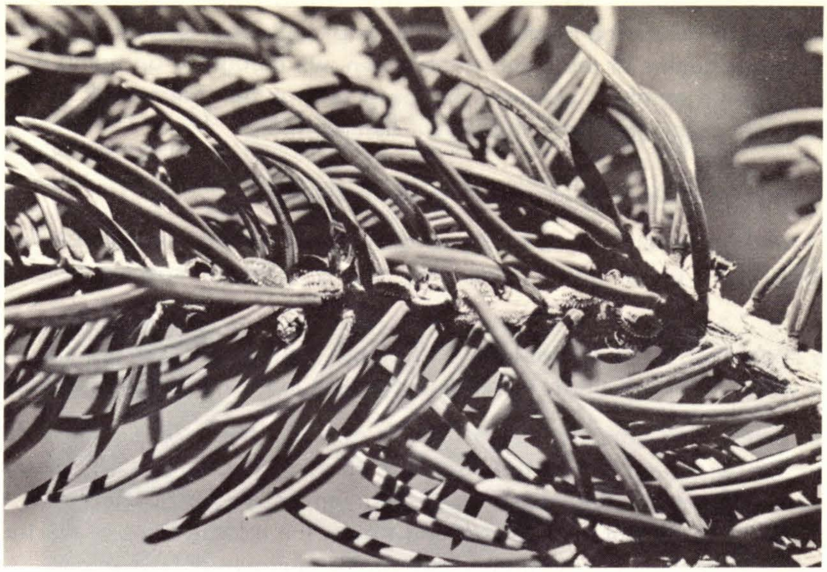
The results of this exploratory work do not eliminate the aphid from the problem. The scalelike form has been observed only in the lower portions of tree crowns, where the symptoms of deterioration are first visible; also the number of aphids is considerably greater in crowns that show advanced symptoms of deterioration.

If the aphid can cause symptoms of crown deterioration, there remains the problem of determining its exact role in killing foliage and branches. Examination of data shows that the number of aphids on a twig is not excessive, in the sense of being massed. This suggests that if aphids are responsible for this deterioration they must either inject a toxin into the shoot, or they could be carriers of a disease organism.

Spruce Mealybug

The spruce mealybug, *Puto* sp., is a serious pest of Engelmann spruce in southern Utah, where about 60,000 acres are now infested at epidemic levels. Infestations occur at altitudes above 10,000 feet in three widely separated areas: Thousand Lake Mountain, on the Fishlake National Forest; Griffin Springs on the Aquarius Plateau; and Barney Top on the Dixie National Forest north of Bryce Canyon National Park. The Thousand Lake Mountain infestation was first reported in 1939 and has remained at epidemic level. The Griffin Springs and Barney Top infestations were not discovered until 1954. Taxonomists and other entomologists studying mealybugs have classified this spruce mealybug in the genus *Puto* as a new and undescribed species.

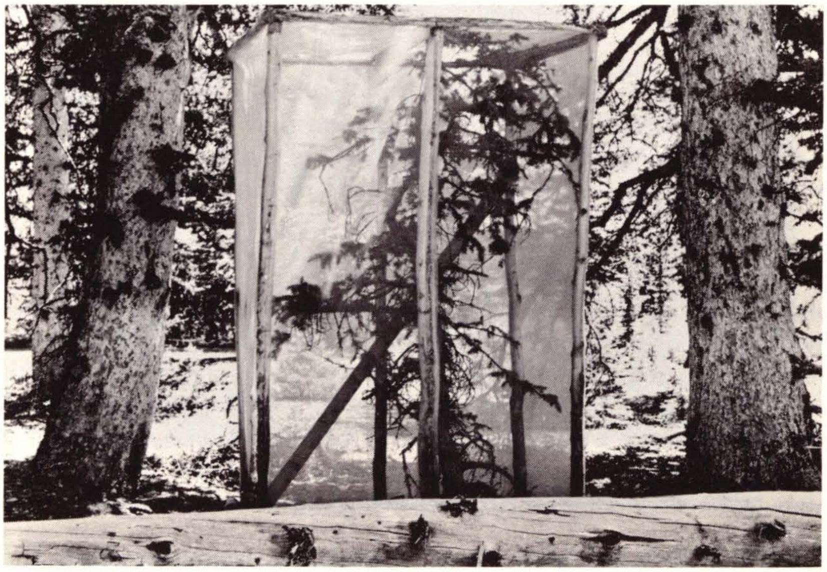
The mealybug feeds on both foliage and terminal twigs, and causes considerable damage as tree deformity, limb killing, and reduced vigor. In the Thousand Lake Mountain infestation some mortality to reproduction is occurring.



Mature female mealybugs feeding on Engelmann spruce twigs

Since this insect may affect future management and utilization of high altitude spruce timber in southern Utah, limited research was started in 1955. Main objectives of the study are: (1) determination of the mealybug's life history and habits; (2) tentative evaluation of insect predators and parasites for controlling the mealybug; and (3) assessment of the importance of the mealybug as a pest of Engelmann spruce.

Manipulation or introduction of biological control agents appears to offer most promise for controlling epidemic populations of this pest. Studies of imported and native ladybird beetles have been under way for three seasons. Results of small-scale experiments have been encouraging thus far, but further study is necessary.



This cage encloses a mealybug-infested spruce used to rear predaceous beetles

While major details of the life history of the mealybug were being determined, the problem of assessing the destructiveness of the pest was not undertaken. We know that feeding by epidemic populations causes yellowing of foliage, needle drop, limb mortality, some top deformity, and some tree mortality, especially in reproduction and pole timber. But we do not know the degree of mortality of larger trees, if any, or the total effect of repeated feeding. We have yet to learn the relation between population densities and their damage to the host.

Control of Spruce Spider Mite and Spruce Budworm

During the summers of 1958 and 1959, Intermountain Station cooperated with National Forest Administration in conducting a pilot test directed at simultaneous control of the spruce budworm, *Choristoneura fumiferana* (Clem.) and the spruce spider mite, *Oligonychus ununguis* (Jacobi) in Montana. Included in this test was a study of the effects of a miticide added to the DDT spray formulation ordinarily used in budworm control. This study was completed in the fall of 1958.*

Changes in populations of the spruce spider mite and its predaceous mite enemies show some interesting comparisons from the point of view of biological control. During the summer of 1958 the number of spruce spider mites on host trees in the study area greatly increased after an aerial spraying in late June--much more in sprayed than in unsprayed check blocks. This increase continued in 1959. Populations increased generally on all sprayed blocks but remained comparatively static on the check blocks. The most noticeable increases came in the four blocks that had been sprayed with the miticide-insecticide formulation (Genite plus DDT). A lesser increase occurred in two blocks sprayed with insecticide (DDT) only.

Predaceous mite populations were large on most of the sample plots prior to spraying. Following applications, predaceous mite populations were reduced on sprayed blocks but remained static in check areas. By late summer of 1958, predaceous mite populations in the sprayed areas were larger than they had been in midsummer; this indicated that these populations were already recovering. Probably they were, because through the late summer of 1959 predaceous mite populations continued to increase on all sprayed blocks. Predaceous mite populations on the two unsprayed blocks remained static through 1958 and 1959.

Increased numbers of predaceous mites in 1959 probably can be attributed to either of two factors. First, the increase in 1959 may have been a normal response toward stabilizing population. Second, predaceous mite populations may have increased in 1959 as a direct result of increased populations of their host. This possibility is supported by the fact that the size of the increase in predaceous mite populations was directly proportional to the size of the increase in spider mite population on the sprayed blocks.

The predator-prey relation that existed between predaceous mite and spruce spider mite populations was interesting to follow during this study. Prior to the spraying in June 1958, predaceous mite populations were larger than spider mite populations. Following spraying, however, the trend reversed, and by the end of that summer the spider mites outnumbered the predaceous mites. In August of 1959 spider mite populations were appreciably greater than those of the predaceous mites in all sprayed areas. But on the unsprayed blocks that ratio remained static.

The three most important results derived from this pilot test are:

1. Use of the miticide Genite, compound 923, in concentrations of either ½ pound or 1 pound technical grade compound, formulated with 1 pound technical grade DDT in 1 gallon of fuel oil, apparently does not effectively control or suppress spruce spider mite populations when this formulation is aerially sprayed at the rate of 1 gallon to the acre over mite-infested Douglas-fir forests.

2. Use of either of the two Genite-DDT formulations described above or use of the DDT formulation alone apparently reduces predaceous mite populations when aerially sprayed over Douglas-fir forests.

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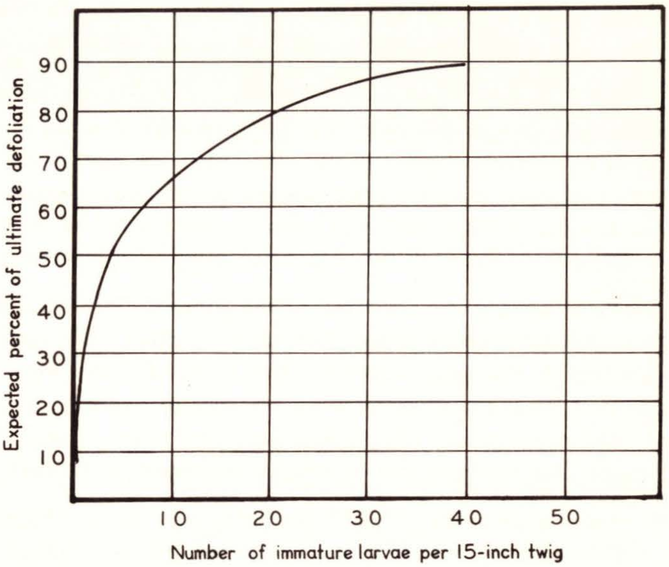
*Design of this study and preliminary results were published in Intermountain Station's annual report for 1958, pp. 18-19; 24-26.

3. The delicate balance between spruce spider mite and predaceous mite populations that exist under natural conditions is disturbed by aerial spraying of the three miticide-insecticide formulations discussed above. It appears that at least 2 years is required for this predator-prey relation to return to normal.

Improving Survey Techniques

During the past several years, improvement of methods for surveying and forecasting trends in spruce budworm populations has been emphasized strongly. Data from records of immature larval populations gathered in two Douglas-fir study plots in Idaho were used in 1958 to compute a regression for prediction of ultimate defoliation. The accompanying figure presents the form of the curve relating the number of immature larvae per 15-inch twig to the expected degree of ultimate defoliation.



Prediction of ultimate defoliation from immature budworm larval populations.

Usually four 15-inch twigs per tree are taken at midcrown as a sampling unit. The following table, based on the regression reported above, has been developed for field use relating the number of immature larvae per four twigs.

Prediction of ultimate defoliation based on immature budworm larval populations

Average number of larvae per four 15-inch twigs	*Expected defoliation*	*Coefficient variation*
	Percent	*Percent*
< 0.63	< 25	30
0.64 - 4.22	25 - 50	11
4.23 - 18.07	50 - 75	14
18.08 - 40.79	75 - 90	20
> 40.80	> 90	25

In 1959 the data developed for prediction of defoliation were tested and found to be reasonably accurate in study plots in southern Idaho. Additional tests are planned.

SURVEYS

Defoliators

Cooperative insect surveys with other Federal, State, and private land managers during 1959 revealed that the Intermountain and northern Rocky Mountain states still suffer from numerous and serious forest insect outbreaks. Station entomologists collected and coordinated a large volume of information that developed a picture of general insect conditions throughout the station territory. Some of the more important outbreaks reported during the past few years are still active, new ones have arisen, and a few species less frequently observed have increased in numbers.

Spruce budworm.—The spruce budworm is still a prominent pest in Montana and Idaho. 1959 saw little change in the Montana epidemic. Most of the available Douglas-fir type east of the Continental Divide is infested, and damage has been severe in some areas. Little serious damage has occurred west of the Divide in the mixed stands of the larch--Douglas-fir type, and in southern Idaho most infestations either decreased in size and intensity or remained relatively static. About 4 million acres of Douglas-fir and true firs are infested in these two states.

Larch casebearer.—First discovered in Idaho in 1957 on western larch, the casebearer is now found over practically all of northern Idaho and eastern Washington--a total area of some 8,000 square miles. However, heavy infestation remained about the same as in 1958 over 15,000 to 20,000 acres near St. Maries, Idaho.

Lodgepole needle miner.—Infestations of the lodgepole needle miner, an important pest in lodgepole pine forests in this territory, have appeared and subsided periodically since 1938. The latest outbreak appeared in Idaho in 1958. It has increased in both extent and intensity and now covers about 104,000 acres; the increase probably will continue in 1960.

Pandora moth.—Last June the pandora moth, an unusual forest insect pest, appeared in lodgepole pine stands in the Uinta mountains on the Ashley National Forest. Inspection of the area revealed an infestation covering about 15,000 acres. By September, larvae had pupated in the soil. Examination of some of the pupae revealed mortality believed to be caused by a pathogen. Pandora moths have a 2-year cycle and in this outbreak will overwinter in 1960 as partially grown larvae. Defoliation during the year probably will be light.

Sawflies.—From Montana to the desert country of Nevada, several species of sawflies appear to be increasing in numbers. During 1959, in the northern Rocky Mountain states at least six different species were collected on Douglas-fir, ponderosa pine, limber pine, lodgepole pine, and western larch. In southern Idaho, sawflies were found on Douglas-fir and lodgepole pine. In Nevada, near Pioche, a heavy infestation of sawfly affected about 75 square miles of pinyon pine type. Heavy defoliation of this species is serious in this area because it prevents harvesting pinyon pine for Christmas trees.

Tussock moth.—Several outbreaks of tussock moths have occurred in Intermountain states during the past 5 years. Besides the outbreaks in Owyhee County and near Carson City, noted earlier, about 5,000 to 10,000 acres of ceanothus, willow, bitterbrush, ninebark, ribes, and rosebrush were infested by tussock moth in Idaho in 1959. Occurrence of a virus disease in this outbreak during this first year of noticeable infestation was unusual, and practically eliminated the infestation.

An unusual situation was noted in July on the Targhee National Forest. Dr. James Mielke, forest pathologist at Intermountain Station, observed a tussock moth feeding on dwarfmistletoe in lodgepole pine, but saw no evidence of feeding on the lodgepole foliage. He stated that this feeding on the dwarfmistletoe could prevent seed formation for about 2 years. The species of tussock moth was not determined.

Bark Beetles

Mountain pine beetle.—Stands of old growth western white pine in northern Idaho and western Montana are chronically infested with mountain pine beetle. These infestations fluctuate yearly, but average annual loss ranges from 1 to 5 percent of the stand. Mountain pine beetle activity in lodgepole pine appeared to be at a low level in the northern Rocky Mountain states in 1959, but in the Intermountain states lodgepole stands suffered considerable damage. Of 22 epidemic centers listed in 1959, 8 were included in chemical control projects; 6 of these had already been treated for 2 or more years.

An outbreak of mountain pine beetles in second-growth ponderosa pine has been present in the Crystal Bay area on Lake Tahoe in Nevada since 1949. A cooperative private, State, and Federal control program started in 1958 was not continued in 1959. Surveys in 1959 showed that the beetle population had increased considerably. An infestation in second-growth ponderosa discovered in 1958 on the Boise National Forest was reduced by control operations, but several hundred infested trees remain in the area.

Engelmann spruce beetle.—The Engelmann spruce beetle is still active in many spruce stands in northern Idaho and western Montana. While beetle activity appeared to have decreased in most previously infested areas in Montana, an outbreak on the Kootenai National Forest increased alarmingly in 1959. Nearly all small areas of persisting infestation are associated with logging areas and are remnants of the outbreak that started in 1952. Outbreaks of spruce beetle persist in Utah, southern Idaho, and western Wyoming. Control operations have reduced populations significantly and held losses to a minimum. Even so, the spruce beetle is still quite a problem in many Intermountain spruce stands.

Douglas-fir beetle.—Observations during 1958 indicated an upward trend in populations of Douglas-fir beetle. In 1959 this upward trend was evident in southern Idaho but less noticeable in western Wyoming; an outbreak in southern Utah continued at high level. Several reports of Douglas-fir beetle activity in northern Idaho and Montana were received during the year. Aside from one rather severe situation in the Swan River area (Montana) there were no large outbreaks such as have occurred in past years.

Several lesser insect outbreaks were discovered during the 1959 surveys. These included insects affecting twigs and terminals, and sucking insects such as aphids, scales, mites, and mealybugs. The over-all forest insect situation in the Intermountain Station territory continues to be a rather serious factor in management of forest stands.

The year 1960 is expected to be another one of extensive surveys because of the continued high level of outbreaks. Forest managers fighting these outbreaks will rely on Intermountain Station entomologists for continued technical assistance in conducting suppressive measures. Continued research on the pests highlighted in this report, as well as on others in this region should give us better understanding of the factors that cause rise and fall of insect populations and help us develop better methods of preventing outbreaks and of reducing losses.

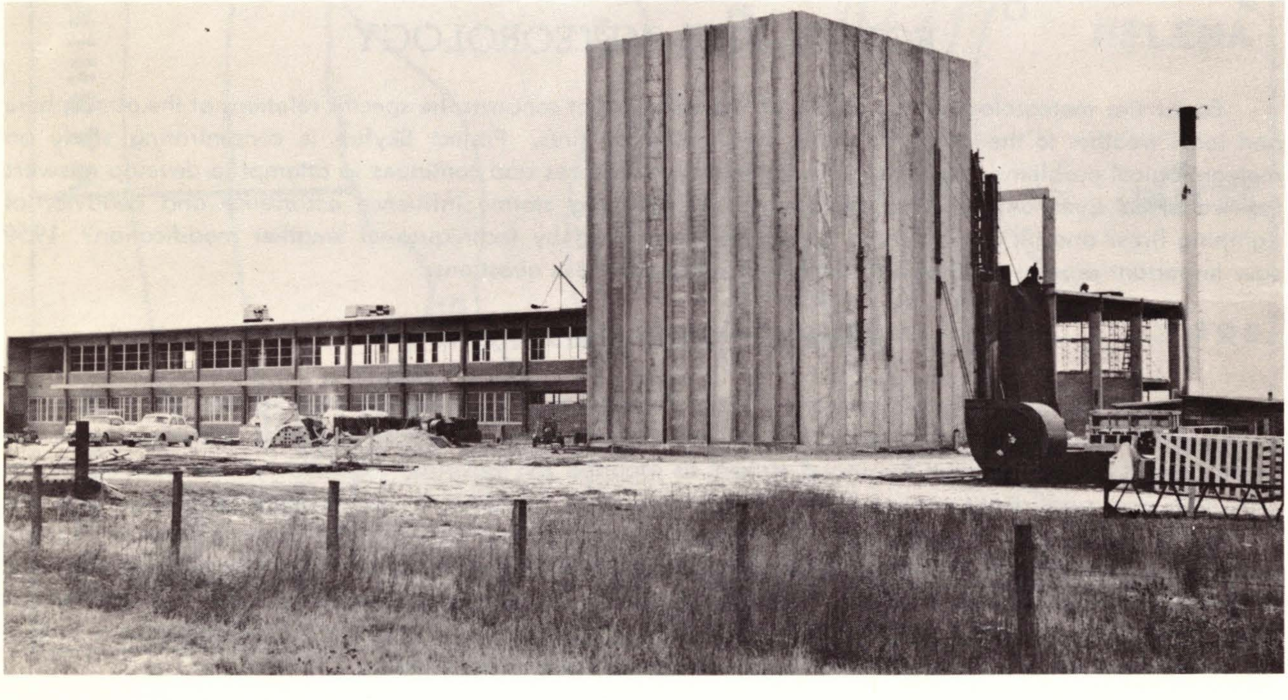
FOREST FIRE RESEARCH

The term "fire science" is constantly developing increased significance to forestry. Fire science is the study of basic phenomena of fire and application of the findings to problems of fire behavior, fire control, and fire use. Fire science comprehends many disciplines--forestry, meteorology, physics, chemistry, engineering, and mathematics--to name only the major ones. During 1959, forest fire research at Intermountain station contributed to the growth of fire science. This scientific growth has presented new information to the field; this, in turn, has helped solve fire problems of nationwide significance as well as local problems of the Intermountain West and Alaska.

NORTHERN FOREST FIRE LABORATORY

April 24, 1959, was a momentous date for forest fire research. On that day ground was broken at the site of the new Northern Forest Fire Laboratory building at the Missoula County Airport. The 36,000-square-foot structure is adjacent to the Region 1 Aerial Fire Depot and Smokejumper Center.

By the end of 1959, the laboratory building was nearly half completed. The Division of Forest Fire Research expects to move into the building during the summer of 1960 and has planned research operations to start in the fall. Important facilities include two wind tunnels-- both high and low velocity; a special controlled temperature-humidity cabinet; and separate laboratories for experimental and analytical work in chemistry, fuels, photography, meteorology, and fire physics.



Northern Forest Fire Laboratory under construction, December 28. Office and laboratory space on left; prestressed concrete combustion chamber and wind tunnel section (right rear) are nearing external completion.

After calibrating the wind tunnels and other equipment and then training laboratory personnel in their use, we can proceed to the new research programs; current work can advance, strengthened by the improved facilities. Additional research personnel will be recruited and trained to utilize the research facilities fully.

Development of the Northern Forest Fire Laboratory presents opportunity to improve presentation of results of fire behavior research and to further the development of a universal system of fire-danger rating. A special viewing room will permit groups of observers to watch demonstrations of fire behavior. Wind tunnels and the combustion laboratory will enable significant studies of the specific effects of wind velocity, air moisture, temperature, and fuel moisture on ignition and fire spread--all essential to development of a national system of fire-danger rating.

We intend that the Northern Forest Fire Laboratory become a fire science center where forest protection personnel can enrich their professional knowledge of fire behavior.

FIRE PHYSICS RESEARCH

One result of the development of the Northern Forest Fire Laboratory is the planning of new research in fire physics. Model fires will be studied under controlled atmospheric and fuel conditions to learn how individual forest fire phenomena are influenced by certain variables that govern ignition, buildup, and spread of fire. A preliminary problem analysis for fire physics research has been prepared as a foundation for the experimental program. A cooperative research program arranged with Washington State University will strengthen the technical stature of this fire physics project. Study of model fires in the combustion laboratory will start in 1960.

FOREST FIRE METEOROLOGY

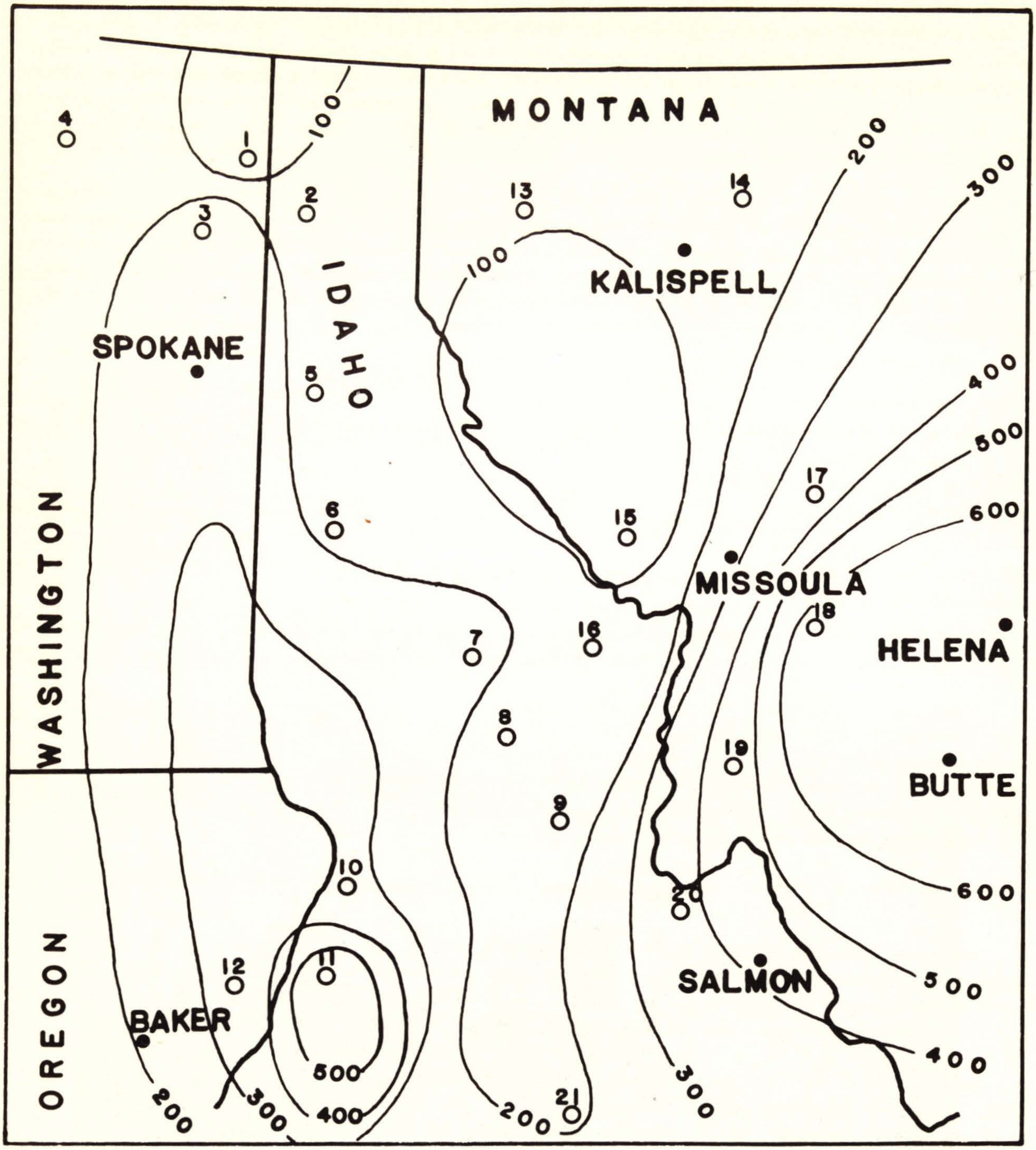
Forest fire meteorology is the phase of fire science that concerns the specific relations of the atmosphere and local weather to the ignition, spread, and control of fires. Project Skyfire is concentrating study on meteorological problems associated with lightning-caused fires and continues to attempt to develop answers for two critical questions: (1) What characteristics of lightning storms influence occurrence and behavior of lightning fires? and (2) Can lightning fire danger be reduced by techniques of weather modification? 1959 saw important progress on research designed to answer these questions.

Lightning Storm Characteristics

Survey of lightning storms from the Project Skyfire network of lookout stations has yielded considerable new information on lightning occurrence and characteristics. The accompanying diagram shows the mean annual density of cloud-to-ground strikes, as reported by lookouts, for much of the northern Rocky Mountain area and identifies several critical lightning zones. This survey has revealed that about one-half of the fire season (July-August) lightning storms last for only 30 to 90 minutes. Nearly one-half of all storm periods have fewer than 10 cloud-to-ground strikes and only 5 percent of the storms have more than 100 strikes to ground each; however, this 5 percent of the storms produces one-third of the total number of lightning strikes. So-called "dry" lightning storms are common during the fire season; nearly one-half of the July-August storms during a 4-year period had less than 0.1 inch of rain.

Other studies of lightning storm characteristics made in field areas specially instrumented to measure electrical properties of lightning strikes have shown that about one-fourth of all discharges from a lightning storm are cloud-to-ground strikes. Records from instruments have also shown that forest fire lookouts usually see only about 20 to 25 percent of all cloud-to-ground strikes.

These studies of storm characteristics may well result in improvements in lightning fire control. One of these would be the development of lightning fire probability maps for use in fire detection and suppresion


MONTANA
IDAHO
WASHINGTON
OREGON
SPOKANE
KALISPELL
MISSOULA
HELENA
BUTTE
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Mean annual density of cloud-to-ground strikes per 1,000 square miles, July-August 1955-58

planning. Another would be a method for predicting the times and places where lightning fires may reach varying degrees of danger. Still to be answered is the question of whether fire-starting strikes are more intense than other strikes.

Weather Modification Experiments

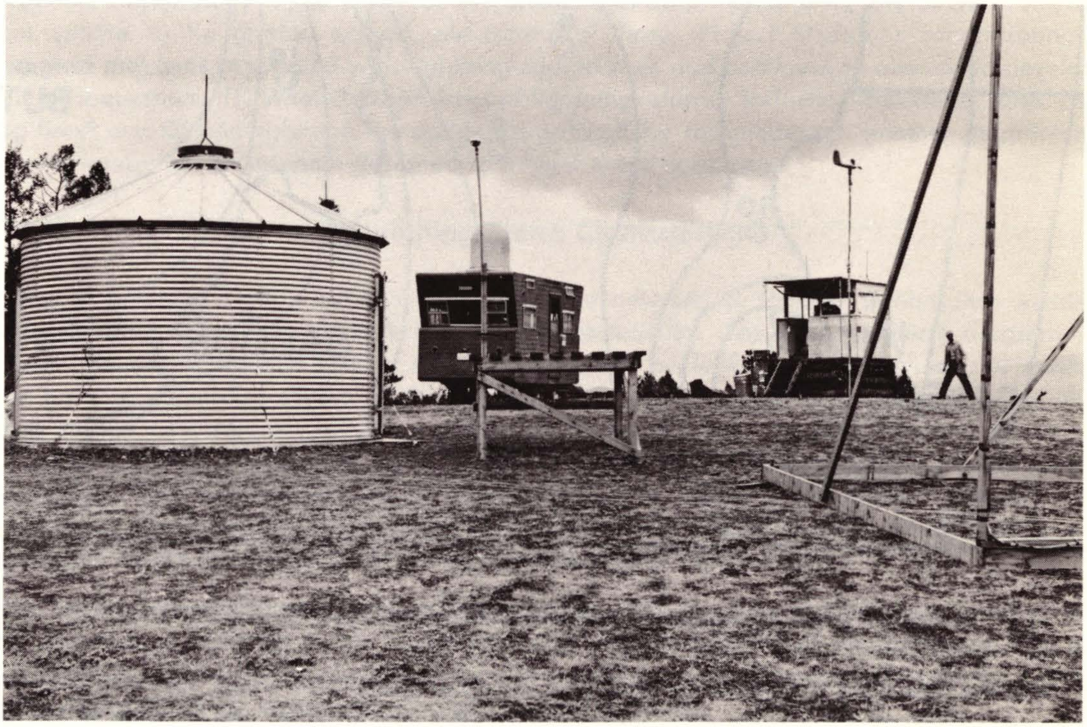
Completion of 3 years of exploratory cloud-seeding research has led to some tentative conclusions about the possible results of using silver iodide to modify lightning storms. More important, these results now permit the design of experiments aimed specifically at determining the effects of silver iodide seeding on the characteristics of lightning discharges.

Theoretical studies of a lightning storm model and experiments with both aerial and ground-based seeding indicate that significant results can best be obtained by delivery of a large quantity of silver iodide nuclei (10,000 or more per liter of air) at cloud base. The best method available for delivering this many nuclei uses airborne silver iodide smoke generators. These tentative conclusions are based partly on results summarized below from 28 observations of lightning characteristics under seeded and nonseeded conditions.

Seeding treatment	*Estimate of nuclei/liter at cloud base*	*No. of cases*	*Average electrical moment Coulomb-kilometers*	*Standard deviation*
No seed	Less than 10	8	232	121
Ground generator	50 - 300	17	92	26
Aerial seeding	Greater than 10,000	3	42	6

Deerlodge National Forest Experiments

Project Skyfire has demonstrated need for conducting experiments in an area having high frequency of lightning occurrence, where electrical characteristics of the discharges can be measured, and where results

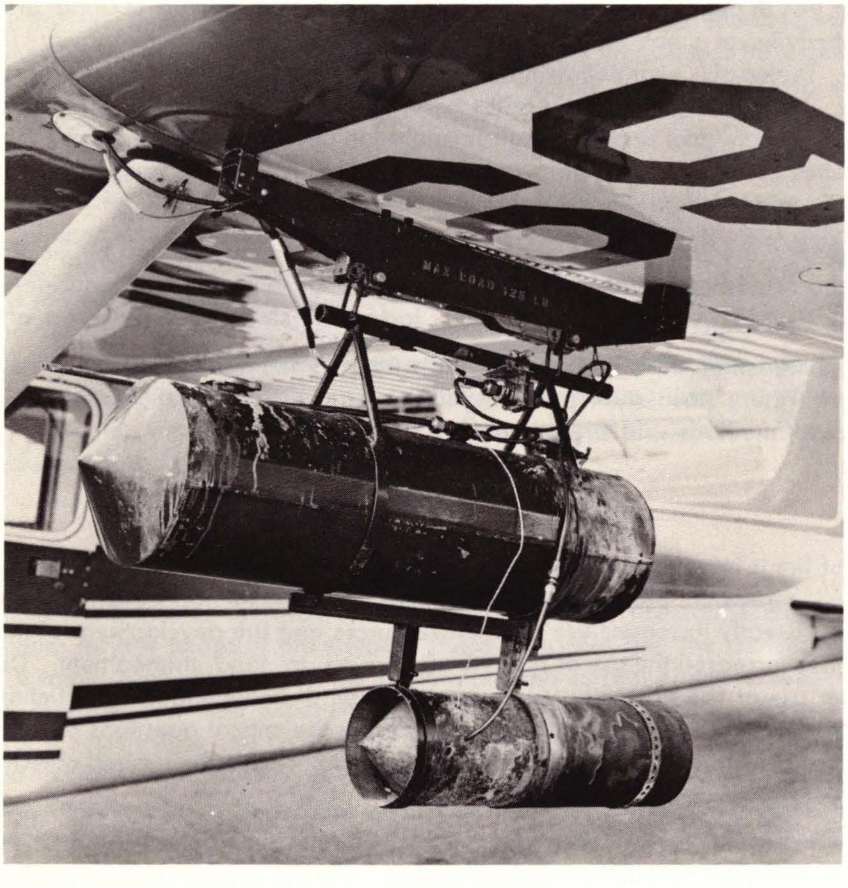


Control site for lightning research area, Deerlodge National Forest. Left: electrically-shielded laboratory (Weather Bureau) with instrument rack and loop antennas. Center: radar trailer and wind equipment (Forest Service). Right: lightning observation station from which field meter and lightning spotting network are controlled.

of seeding can be evaluated. Such an area is available near Philipsburg, on the Deerlodge National Forest, some 50 miles southeast of Missoula. During 1959 we began instrumenting this area and making other preparations for lightning storm experiments. Total instrumentation will include a network of electric field meters connected by land line to a central recording unit, a mobile radar unit, several weather and lightning observation stations, lightning strike counters, and time-lapse photographic units. Completion of instrumenting in 1960 will make possible the basic studies of lightning discharges mentioned above as well as experiments aimed at testing the effects on lightning of intensive silver iodide seeding.

This site on the Deerlodge National Forest will also be used by the Physical Science Laboratory of the U. S. Weather Bureau in basic research of the electrical properties of lightning. The Weather Bureau will use different techniques and tools from ours, but the Forest Service and Weather Bureau research groups are at once independent and interdependent: each complements the other. This double approach to difficult problems of lightning research adds much strength to the over-all program and in no way involves duplication of effort. The two groups will carry on an intensive 2-year program in this experimental area.

Future experiments in seeding lightning storms will require a high output, airborne silver iodide smoke generator. During 1959 we developed a wing-mounted ramjet type generator that can be carried on light aircraft. This completely self-contained unit burns silver iodide in an acetone solution that is fired by an electrical spark activated from controls in the airplane cockpit. Preliminary tests indicate that this new generator will meet Project Skyfire requirements for aerial seeding. During 1960 at least four of these airborne generators will be used in the lightning research program. In a randomized experiment, seeded and nonseeded lightning storms will be compared.



Experimental silver iodide smoke generator suspended from bomb rack of a Cessna 180

National Science Foundation Support

Project Skyfire received an important boost late in 1959 when the National Science Foundation approved a grant of $63,000 to Intermountain Station for support of the lightning research program for 2-1/2 years beginning January 1, 1960. Two specific objectives of the research to be financed partly by the National Science Foundation are: (1) to obtain basic information on the frequency, type, and electrical characteristics of lightning discharges from thunderstorms and to evaluate this information in relation to theories of thunderstorms and atmospheric electricity; and (2) to determine the effects on the frequency and electrical characteristics of lightning discharges when clouds are heavily seeded with silver iodide and to evaluate the results in relation to theories of lightning.

FIRE BEHAVIOR RESEARCH

Logging Slash Flammability

Research on the flammability of logging slash, carried on at Priest River Experimental Forest outdoor slash laboratory, was designed to determine how the flammability of logging slash varies according to species, age, and volume of slash per acre. These experiments, now more than three-fourths completed, have shown that the amount of slash that will result from cutting a stand of timber can be estimated with reasonable accuracy from measurement of standing trees.

During the first year after logging, the *amount* of slash is the main fuel factor influencing fire spread, but lesser effects of species characteristics are noticeable. Moisture content of fine slash fuels drops to a critical 10 percent or less in periods varying from 2 weeks to several months. During fire season, slash in exposed locations--heavily cut areas on southerly aspects--reaches high flammability rating within one month after cutting. During the year following timber cutting, species becomes an important factor influencing flammability. Trees that drop their needles become less flammable because of the great change in fuel arrangement and the physical and chemical deterioration of the needles themselves. Slash flammability decreases in all species during the year following cutting. The amount of decrease varies so widely by species that this factor must be considered in planning slash control measures.

A station Research Paper on logging slash flammability is scheduled for publication early in 1960. It will present the characteristics of light, medium, and heavy slash of the nine principal coniferous species in the Intermountain West and will show flammability factors for slash for 2 full years after timber cutting.

The series of experimental slash burnings at Priest River Experimental Forest will be completed during the 1960 fire season. Future slash studies will include experiments under fully controlled burning conditions and studies of disposal methods and fire prevention.

Prescribed Burning Research

Beneficial use of fire is important in the Intermountain West. Slash burning, reduction of residual fuel, removal of unwanted vegetation, preparation of seed beds, and other forest activities require intelligent, controlled use of fire. Greatly increased use of forest resources and the development of more intensive management practices have increased the use of prescribed burning in land managment. Developing reliable techniques for proper use of fire primarily requires application of knowledge of fire behavior. Our research related to prescribed burning is directed toward answering the critical questions of when to burn, how to predict behavior of the prescribed fire, and how to burn so as to achieve the desired objective.

During 1959 this division started research related to prescribed burning. After preparing a research operations plan, we instrumented two prescribed burns to obtain background information on weather and fuel moisture factors, and prepared forms for assembling essential data on future prescribed burns. Time-lapse movies recorded the active burning period on one prescribed fire.

Fire Behavior Training

The second national Fire Behavior Training School was held at Alexandria, La., in January and February. It was conducted along lines similar to those of the first training school, held at Missoula in 1958. Again the Forest Fire Research Division participated in development and presentation of the course in cooperation with other Forest Service experiment stations and regions, and the U. S. Weather Bureau.

This year we tried closed circuit television as a means of showing fire behavior demonstrations in wind tunnels to trainee groups. Further development of fire behavior training techniques will be a function of the Northern Forest Fire Laboratory.

FIRE CONTROL RESEARCH

Alaska Project

The comprehensive problem analysis of forest fires in Alaska, now in preparation, will provide the foundation for a fire research program in the 49th state. Moreover, this problem analysis will provide information needed by Alaska fire control agencies in planning and managing fire prevention and suppression operations. Last year we completed analysis of fire reports covering a 9-year period and started similar comprehensive analyses of fire and weather factors in the Alaskan interior.

Before the start of the 1959 fire season, a member of the Northern Forest Fire Laboratory staff went to Alaska to prepare for fire research field activities. Two Bureau of Land Management field crews were trained in gathering data at the site of going fires. Arrangements were made to expand and improve the experimental fire-danger rating system. At the end of the season, data from these operations, including data collected at the scene of 11 fires in the Alaska interior, were analyzed. By the year's end, preparation of a full report on Alaskan forest fires was nearing completion.

An important event for Alaska fire control was the beginning of smokejumper operations in 1959 by the Bureau of Land Management. Organization of the smokejumper program was one of the first recommendations made by fire research for Alaska. A 16-man crew trained at the Forest Service Smokejumper Center in Missoula moved to a new BLM smokejumper station at Fairbanks at the beginning of the 1959 season. We expect research to develop needed fire control methods to complement the smokejumper operations. Some of the possibilities include better predictions of fire occurrence and behavior; new systems for fire detection, including use of radar to track lightning storms; integrated program of fire-danger rating and fire weather forecasting; and further application of fire retardant chemicals to the special fuel and weather problems of Alaskan forests.

Fire-Danger Rating

Research and field experience with the Intermountain system of fire-danger rating has developed three fundamental principles for this phase of fire science. These principles are: the cumulative effects of weather; current effects of weather; and interpreting the cumulative and current effects of weather for specific times, places, and fuels. Research and field experience with all current systems of fire-danger rating have demonstrated the need for a system that can be applied universally. A national project is under way to develop such a system, and this division is helping in the program. Fuel moisture is being studied thoroughly at the Boise Basin and Priest River Experimental Forests to determine the response of various types of heavy fuels to cumulative and current weather factors. In Alaska, the special problems incidental to prolonged daylight during the fire season and the responses of massive volumes of fine fuels to this environment are being studied in relation to development of a universal fire-danger rating system.

Fire Equipment Research

Fire science involves use of a wide variety of instruments and equipment both in research and in controlling fires. Part of our effort is devoted to development of instruments and equipment.

In 1959 we completed development of several items of fire weather and fire-danger rating equipment. Testing has been completed, and reports and specifications have been prepared for a belt weather kit, rain gage, electric fan psychrometer, and totalizing wind counter. A portable fire weather station and a lightweight, knockdown weather instrument shelter were modified and further field tested. A fire weather station that records data photographically was field tested last year. A fully automatic recording fire weather station has been bench tested and is in final stages of development. Work has been started on an atmospheric stability recorder for use on patrol aircraft; this instrument will provide atmospheric measurement of temperature, dew point, and barometric pressure for use in fire behavior evaluations.

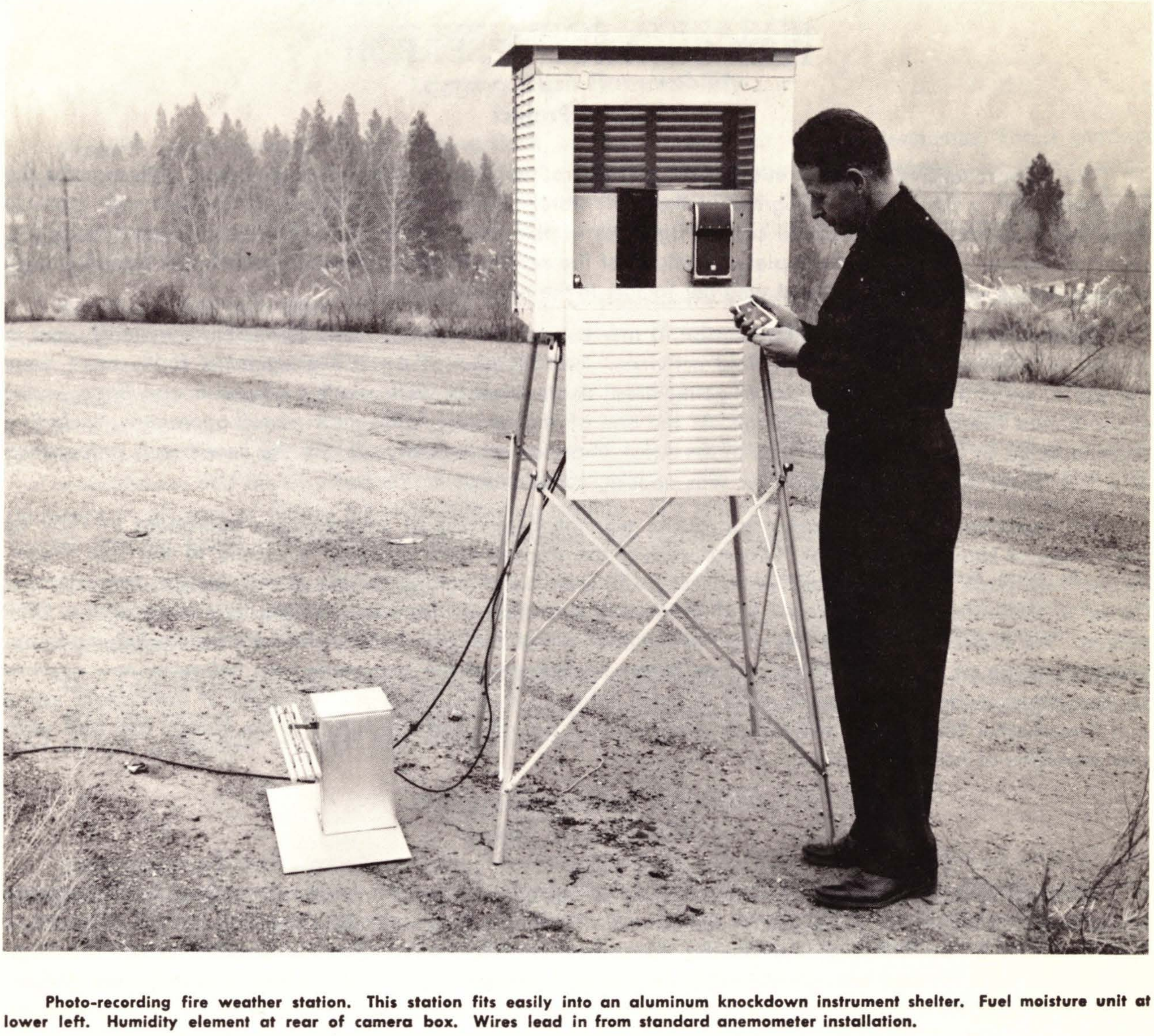


Photo-recording fire weather station. This station fits easily into an aluminum knockdown instrument shelter. Fuel moisture unit at lower left. Humidity element at rear of camera box. Wires lead in from standard anemometer installation.

FOREST ECONOMICS RESEARCH

Both phases of the program of the division of Forest Economics Research made good progress during 1959. The Forest Survey unit finished its field work for the State of Colorado and started the reinventory program in northern Idaho. The Forest Economics section continued its economic studies of the Clark Fork area of Montana and of the North Slope area of the Uinta Mountains in Utah and made pilot studies of methods of improving data collection on forest inventory plots.

FOREST SURVEY

We completed inventory plot work for the initial forest survey of Colorado this year despite heavy September snows that threatened to end the field season early. Survey teams covered the entire area of the San Juan and Rio Grande National Forests and portions of the White River and Gunnison National Forests, together with other public and private forest land in southern Colorado. These field plots provide the basis for calculations of timber volume and growth. Area data for the national forests are being compiled by Region 2 from forest type maps being prepared on each forest. Area and volume data for the Forest Survey in Colorado will be tabulated and compiled by IBM 650 electronic computer. This phase of the Forest Survey program is being directed by the data processing unit at the Pacific Southwest Experiment Station at Berkeley, California.

In 1960 we shall concentrate field work in Wyoming and the adjoining Black Hills portion of south Dakota; we expect to complete the inventory plot work in these areas by the end of the season.

In the northern Rocky Mountains the Forest Survey program is now on a maintenance, or reinventory, basis since the initial surveys were made several years ago. In western Montana, field plot work for the reinventory was completed late in 1958. During 1959 data on forest area by type, stand size, and ownership have been gathered for the entire region. Compilation of the area and volume data is now under way.

During the past year, our Survey field work covered approximately 1 million acres of forest land in northern Idaho. This work was done in cooperation with the St. Joe National Forest and Region 1. We tried several new techniques in this field program, including (1) determination of forest area by photo classification of a systematic sample of 1-acre plots with adjustments by field examination of a portion of these plots, and (2) a method of more accurately classifying stand conditions in a sample acre by using several small plots distributed throughout the acre. Although the area involved was not large enough to provide definite conclusions, both techniques offered sufficient promise that they will be continued with some modifications in the 1960 field program. Our plans for 1960 call for extending the inventory field work in northern Idaho to cover Benewah, Latah, Lewis, and Nez Perce Counties.

Timber Cut

Our annual survey of Christmas tree exports from Montana in 1958 was conducted early in 1959. This survey was made possible by the cooperation of several State and Federal agencies and the railroad companies operating in Montana. Exports for 1958 totaled nearly 3.6 million trees and indicated that the decline that set in following the all-time peak of 4.2 million trees in 1956 had continued but at a less precipitate rate than was observed in 1957.*

Personnel of this division cooperated with the Bureau of the Census in the survey of 1958 lumber production in Idaho and Montana. This survey was part of the Bureau's Census of Manufactures. We contacted, by mail and personal interview, 455 sawmills in Idaho and Montana, or about half of all sawmills in the two States. General supervision was also provided for a similar cooperative survey of lumber production in Arizona and New Mexico made by personnel of the Rocky Mountain Forest and Range Experiment Station. Results of both these surveys will be published by the Bureau of the Census.

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*Full details of this survey and of the pole production survey appear in Research Notes 65 and 72 by Alvin K. Wilson.

Our annual survey of commercial pole production in Idaho, Montana, and northeastern Washington for 1958 was conducted in cooperation with the Rocky Mountain Pole Treating Association. Production in 1958 totaled 340,231 poles--more than one-third less than the 1957 total. This decrease is attributed to the general business recession of 1957-58 rather than to any significant change in market demand.

Estimates of the 1958 output and value of all primary forest products were made for the states served by Intermountain Station. Total value of these products (at local delivery points) in Idaho, Montana, Utah, Nevada, and western Wyoming was estimated at $143 million. Products from Idaho and Montana made up 97 percent of this total. Sawlog production in the entire area was estimated at 2.9 billion board feet, with a value of $119 million, or 83 percent of the value of all products. Pulpwood logs, bolts, and chips were valued at $9 million.

Aerial Photo Interpretation

Training continued to be a major item in our photogrammetric program. Division personnel participated in training seminars with Region 4 and the Indian Service and gave individual training to station technicians and to several foreign visitors.

In response to widespread requests, we are preparing a handbook of photo interpretation and measurement for instructors use. This book will capitalize on training experience developed over several years and will include discussion of training methods and sample training problems. The handbook and kits of problems, photos, and photogrammetric aids will be available early in 1960.

An aerial volume table for ponderosa pine in the Rocky Mountains is in process of publication. It is based on plot data from Idaho, Colorado, Utah, and South Dakota. It provides volume tables expressed in International 1/4-inch, Scribner, and cubic-foot volumes.

FOREST ECONOMIC STUDIES

Forest management in the Mountain States region is rapidly becoming more intensive. Recent trends and outlook studies point to the necessity for intensifying the forestry effort in response to the increasing demand for wood and growing pressures on the forest.

The prospects raise several direct, practical questions heretofore considered to be academic rather than real. Essentially, however, they can be summarized as three over-all questions: (1) How far do prospective values justify carrying present forestry measures? (2) What combination of uses, such as timber and water, represents the best utilization of wild land? (3) What successive steps represent the proper buildup of effort?

In anticipation of need to answer these questions, this division has concentrated mainly on broad studies designed to help orient and to provide a basis for policy and program determination. This program was represented by two major publications in 1959, namely, "Resource Base for Expanded Markets in the Mountain States" by Roscoe Herrington and "Production-Distribution Trends and Freight Rates as They Affect Mountain States Lumber Producers" by S. Blair Hutchison. Herrington's report attempts to assess in general terms the extent of the natural resources of the Mountain States and the resultant opportunities for expansion. Hutchison's paper examines the changing place of Mountain States lumber producers in the national market and the apparent significance of freight rates in this problem.

A study of timber industry opportunities in the Clark Fork drainage of western Montana has been under way for several years. The purpose of this study has been to estimate the industrial opportunities in that area and to interpret what these opportunities require and justify in the way of management programs.

An economic study of the North Slope area of the Uinta Mountains in Utah is in its second year. This study, described in last year's annual report (pp. 41-42), is analyzing the problems of program development for a smaller area. We have made detailed classification of the condition of stands in the area, and the data are being assembled for analysis and decision on the management steps needed.

The Clark Fork and North Slope area studies have brought to a head the growing dissatisfaction with the data base for forestry. Experience gained in these two studies has underlined the contention that Forest Survey data do not adequately provide the kind of inventory information needed to determine forestry needs. The economics research group has therefore explored the field of sampling techniques and inventory surveys to determine what types of data are needed and how they can be obtained most effectively.

The principal conclusion to date has been that the greatest weakness of past timber inventories is the absence of information about the distribution of the trees. In other words, it is not enough merely to know how many trees are standing in a given area: it is also necessary to know how they are distributed in relation to each other. Such information is not available from the 1/5-acre plots normally taken by the Forest Survey.

Foresters in other parts of the United States have recognized this problem and are developing techniques to deal with it. This station has been experimenting with substitution of a grid of 16 small plots in each acre for the 1/5-acre plot. Within each small plot the crop tree is recorded and described, and the excess trees are likewise tallied. The surrounding stand is considered in determining whether there is a crop tree in each plot. These 16 samples, therefore, tell us three things for each acre: (1) how many trees there are; (2) which of the trees are more important; and (3) how the trees are distributed.

The management needs of a forest properly sampled can be determined by analyzing each individual acre separately. This process contrasts with past survey procedure, which is based on averaging groups of plots (as for a particular type size of stand) to obtain a composite picture to a broad stand category. This composition procedure hides the stand variations that are the basis for forest management.

Study of this inventory technique will continue in 1960.

FOREST UTILIZATION RESEARCH

Despite voluminous publicity given to the many substitutes for wood, wood in solid or fiber form plays an all-important role in man's everyday living. Americans today consume tremendous volumes of lumber, crating, boxes, flooring, plywood, paper, composition boards, and other timber products from the forest. Modern man would be without a place to live, a book to read, or packaged groceries to eat were it not for wood.

By the same token, fulfillment of other demands that are being made on our forests--to furnish a place for recreation, a place to hunt wild animals and birds, a place to fish, a source of pure water, a place to graze domestic livestock--frequently depends upon developing a program of conservative utilization of the timber crop. The balance between wise use and resource exploitation is often delicate, particularly in regions like ours where soils are often thin, water is often scarce, mountains are generally steep, and biological factors are frequently unfavorable for easy perpetuation of the renewable resources: forage and timber.

One of our greatest problems, therefore, is to find better ways to harvest the timber crop, more efficient ways to convert it into consumer goods, and new ways to approach more nearly full utilization of the resources we have inherited. The mission of this division of Intermountain Station is to see that research leading toward this objective is stimulated by any or all who are qualified and equipped; to assist in interpretation of results of such research and encourage their early application; and to assist in the actual research wherever skills and manpower fit. Ours is still a modest program in relation to the many apparent needs, but each year some progress is made; 1959 was no exception.

TIMBER GROWTH PROBLEMS

There are indications that timber growth can be regulated by various management techniques to produce trees having "tailormade" specifications. One such opportunity exists with western larch. Larch is in high demand for such specialty products as poles and veneer logs. The species lends itself to management manipulation so that trees with optimum characteristics for specific end-use can be grown. This division, collaborating with Forest Management Research, has started a study as part of the research program at Missoula. Field phases of the survey of growth conditions in natural stands were completed in the summer of 1959.

The analysis of spiral grain in poles, installed in Newport, Washington, has been completed. Final reports are being prepared, and evidence from early analyses strongly points to some spectacular conclusions. Poles with left-hand twist continue to wind and unwind severely after installation. Straight grained poles perform better, but not so well as poles having right-hand twist. Results of the experiments are conclusive enough to suggest modifications in standard pole specifications.

TIMBER HARVESTING PROBLEM

If a survey were made of forest industries and forest land managers, the number one problem in utilization might well be listed as "logging." Problems associated with logging vary among forest types, but the general problem of efficient logging is paramount from both an economic and a biological standpoint. This past year we completed preliminary analysis of the complex harvesting problem and now identify at least four distinct segments:

1. Logging steep watersheds where soil and water values are jeopardized and where economics places certain limitations.

2. Logging small stem timber where distances from mill and market combined with unfavorable terrain make conventional methods unsatisfactory.

3. Recovery of scattered mortality in previously logged areas where high value old growth losses approach or exceed gross growth.

4. Harvesting smaller trees through beneficial thinnings in order to release residual trees so as to attain maximum production.

As an approach to finding desirable means of logging steep watersheds, Intermountain Station is collaborating with Region 4 in a logging study on the Payette National Forest. The presale preparation and sale contract were completed during the past year. This division will study production costs when logging gets under way in 1960.

TIMBER PROCESSING PROBLEMS

Last year we reported that 1959 should be a "boom year" for lumber production. This prediction was only partially realized: orders exceeded production for the first part of the year, and prices were firm, but the impact of delays in housing legislation, adjustments in interest rates, and the steel strike closed the gap between supply and demand. The year 1959 was a good year for lumber production, but was below early expectations.

This is the era of finished consumer goods. No longer does the professional builder or even the do-it-yourselfer want crude raw materials to saw, drill, plane, or paint. He wants unitized components, prefinished, predrilled--all but put in place. The nearer that forest industries move toward satisfying this consumer desire, the better the industry will be able to compete with nonwood materials. Several mills in this area now produce these consumer type materials: prefinished paneling, glued-up boards and timber, and overlaid veneer and lumber. The regional economy is also bolstered by the diverse products of paper mills, plywood factories, and particle board plants. In each of these industrial segments we observe continued progress, plant growth, and general expansion.

Interest in pulp making still runs high in this area. One new mill has just completed a pulp mill to supply two already completed container plants. Another company has just started an expansion of its pulp mill and construction of an integrated paper mill. Still other companies investigate pulp possibilities. The station continues to provide technical data for these investigations.

The Division of Forest Utilization Research again cosponsored small sawmill clinics in Wyoming and Idaho. These clinics, designed to improve operating efficiency of the smaller sawmills, seemingly have had some apparent effect. By now more than 200 individual operators have received technical training and demonstration in conjunction with these clinics. This is the only sawmill training some of these operators have ever received.

The division continues to press for improvements in log and tree grade development, both through participation in regional grade-yield studies and in work with the National Log Grade Committee. Assistance was given this year to two such studies, one in southern Idaho and the other in western Montana. In addition, the division participated in a special log grade conference sponsored by the University of Idaho in April.

The Forest Products Laboratory assisted in making a detailed analysis of milling and seasoning conditions at one study sawmill in southern Idaho. In a separate study, field work for study of the drying of poles in a custom kiln in northern Montana was completed. Detailed results will be reported later.

TIMBER UTILIZATION PROBLEMS

It has always seemed incongruous to us that great effort is spent in conserving the timber resource through its growing, logging, and primary manufacture, only to have it wasted at the construction site through either poor design or poor construction. Waste in end-use should be relatively easy to control: intelligent design and prudent construction could prevent much of it.

In an effort to help local builders and others associated with construction, two clinics were held in Ogden in 1959. The first, in June, was directed at the use of wood in school construction and offered to school board members and their architects reports on the use of wood in other areas. The second clinic, a December meeting, called as an aftermath to a violent and destructive windstorm on October 30, offered builders, architects, tradespeople, and others criteria for wind-resistant construction. These two meetings could serve as pilot tests for future meetings related to good wood construction. Both were successful and should help lead to improved use of wood.

RANGE MANAGEMENT RESEARCH

Range management research at Intermountain Station continues to be concerned with a variety of problems imposed by the semiarid climate characteristic of most of the station's territory, and with diverse problems of winter ranges and spring-fall ranges used by livestock and big game. We are also expanding studies of problems associated with high altitude summer range. In the summer range country, which often has steep terrain, problems of watershed management are closely linked with range management and maintenance. These areas present critical multiple-use problems for research. Many of our research projects are carried on in cooperation with other Federal and State agencies or institutions.

STUDIES ON SPRING-FALL RANGE

Effects of Rotational Spring Grazing

Rotational spring grazing appears to permit considerably heavier use of sagebrush-grass range by sheep than was considered permissible for continuous grazing. Preliminary analysis of a 16-year study at the Upper Snake River Experimental Range, near Dubois, Idaho, indicates that, with rotational use in the spring, ranges hold up nearly as well when grazed at the rate of 44 sheep-days per acre as they did at 28 sheep-days per acre.

The fourth 4-year rotation of the range paddocks in this study was completed in 1957. In 1958 the paddocks were not grazed, and a complete vegetation inventory was made. Four paddocks had received 14 sheep-days per acre of rotational spring grazing plus an equal amount of fall use each year; four others had received 22 sheep-days' use per acre in both spring and fall under the same system. Spring use was rotated so that a paddock was grazed during a different fourth of the spring season four successive years. Fall grazing was continuous and for about the same period every year.

Based on experience with other grazing practices prior to the start of these treatments in 1942, these rates were considered heavy and light stocking. They now appear to be light and moderate rates. Preliminary comparisons summarized in the tabulation below show little difference between the vegetation of the two series of range paddocks at present and little change in each series since the beginning of the study. Furthermore, response in the grazed paddocks was similar to that in the unused paddocks, which suggests that these ranges are in excellent condition. Climatic fluctuations evidently have had more effect than have the different intensities of grazing.

Herbage production in paddocks lightly grazed, heavily grazed, and ungrazed, by forage classes as measured in selected years, was as follows:

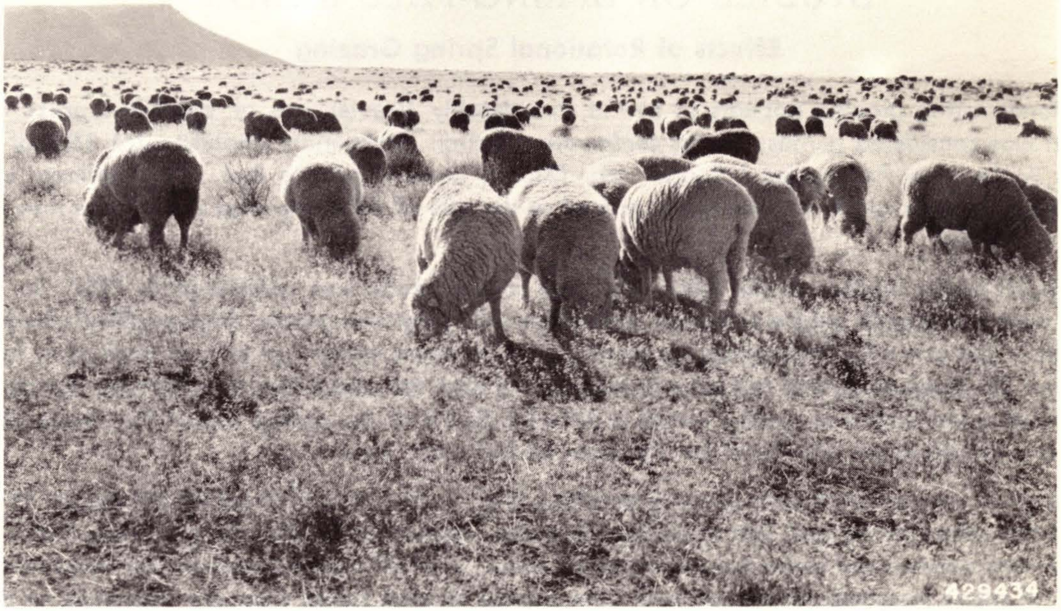
	Grazing use[1]								
	Light			*Heavy*			*Ungrazed*		
Plant types	1940[2]	1949	1958	1940[2]	1949	1958	1940[2]	1949	1958
	Pounds per acre, (air dry)								
Grass	168	129	210	203	114	183	221	252	222
Forbs	45	57	52	58	49	48	246	201	183
Shrubs	530	413	339	482	502	322	590	436	283
Total	743	599	601	743	665	553	1,057	789	688

[1] Light grazing: 14 sheep-days per acre, spring and fall; heavy grazing: 22 sheep-days per acre, spring and fall.

[2] The initial inventory data were taken during a calibration period before the treatments were started in 1942.

Cheatgrass Management

During 1959 we took important steps toward starting a research program on the management of cheatgrass ranges. This program will be a cooperative effort with the Bureau of Land Management. Plans are well advanced and initial studies may begin with the 1960 grazing season. A study area to be called Saylor Creek Experimental Range has been selected south of the Snake River near the towns of Glenns Ferry and Hammett, Idaho, and the installation of facilities has started.



Typical cheatgrass range in Idaho.

This study program is being designed to provide information that will answer major questions about the management of ranges dominated by cheatgrass. We hope to determine the forage value and grazing capacity of cheatgrass range as compared to perennial grass range; also how best to utilize cheatgrass as annual-type range, especially where the native perennials have been completely lost and revegetation is impracticable. If cheatgrass proves to be undesirable, other objectives will be to determine (1) the feasibility and requirements for converting cheatgrass range to perennial range, and (2) how to avoid the encroachment of cheatgrass into perennial grass range.

Initial investigations will obtain information on plant and livestock responses to grazing at various seasons and intensities. This information will be used to develop grazing systems and practices that will be evaluated later.

Crested Wheatgrass Range at Benmore

Yields of crested wheatgrass and brush invasion on Benmore Experimental Range show long-term effects of different grazing practices on spring range. After 11 years, heavily grazed ranges are producing significantly less forage than ranges grazed either lightly or moderately. Light and moderate grazing showed no significant difference in forage production; neither did the four systems of spring grazing that have been tested. The following tabulation shows average forage yields in pounds per acre (air dry) of crested wheatgrass in 1959 after 11 years' application of three intensities and four systems of grazing at Benmore.

Grazing System	*Intensity of grazing*			
	Light	*Moderate*	*Heavy*	*Average*
Rotation	462	435	391	429
Continuous	428	444	242	371
10-day deferred	435	421	406	421
10-day short	445	432	262	380
Average	442	433	325	

Increased invasion by brush, particularly by big sagebrush, was associated with heavy use and a decline in crested wheatgrass. Rabbitbrush also increased under heavy grazing. However, grass growing beneath and near rabbitbrush was nearly as luxuriant as that in the open. Furthermore, this protected grass was greener and more palatable to livestock in the fall than open-grown grass. This suggests that some rabbitbrush might enhance the value of crested wheatgrass range for fall grazing.

We are revising studies on crested wheatgrass range at Benmore. New studies to be started in 1960 include: (1) the effect of different seasons of use and supplemental feeding upon cattle performance and grass production and utilization, and (2) the effects of grazing treatments in controlling or reducing brush invasion of crested wheatgrass areas.

STUDIES ON SUMMER RANGE

Urgently needed research on mountainous summer ranges to determine how best to graze these important multiple-use areas was started in 1959. Three studies started are on very different sites, each representative of large areas of high-elevation sheep and cattle range in the Intermountain territory.

Diamond Mountain Cattle Range

A cooperative study of grazing management of cattle range on the Ashley National Forest in northeastern Utah was started this year. The purpose is to determine which of several systems of cattle grazing is best suited for making maximum use of the available forage over the entire range, and at the same time maintaining forage production near its potential on rolling mountainous topography. Cooperating with us are the Diamond Mountain Division of the Ashley Cattlemen's Association and the Ashley National Forest.

Grazing systems to be studied involve both seeded and native range. They include:

1. One-unit, continuous grazing of native range every year as commonly practiced.
2. A two-unit system which alternates seasonlong grazing of native range one year with complete rest the next year.
3. A three-unit rest-rotation system wherein native range receives complete rest one year, late summer grazing the second year, and early summer grazing the third year.
4. Heavy early grazing of seeded range one year followed by complete rest the next year.
5. Heavy early grazing of seeded range plus moderate late grazing one year followed by complete rest the next year.

In all systems except the first, stocking is concentrated to force more uniform utilization of all the major forage plants and obtain more uniform distribution of cattle over the range. Then a full season of rest is provided to permit recuperation and regeneration of forage plants.

We used the 1959 season as a calibration period to determine approximate grazing capacity and patterns of grazing use on each of seven fenced units in the allotment under similar grazing. The systems will be put into effect in 1960. More than 500 cattle will be grazed for 4 to 5 months beginning June 1.

Mud Creek Sheep Range

In 1959 we also began studies of sheep grazing management on deteriorated, high-elevation range in the aspen zone. The allotment selected for study on the Mud Creek drainage of the Uinta National Forest is primarily aspen-forb-elderberry range at an elevation of 8,000 to 9,000 feet. Prior to 1953 this allotment had been grazed by two bands of sheep that totalled 2,463 head. Allotment analysis studies showed that the area was being overgrazed, with marked downward trends in both vegetation and soil conditions.

Sheep range on Mud Creek drainage study area.

In 1953 stocking was reduced two-thirds, and since then the allotment has been grazed by only one band of 800 head. Remarkable improvement is evident and several stages of recovery are represented. On considerable portions of the area the plant cover still is in early stages of secondary succession with large amounts of annual weeds and very little grass. Generally, however, sedges, bluegrass, wheatgrasses, and bromegrass are replacing tarweed and other annuals on many formerly depleted areas.

Because of the various range conditions at hand, the area offers good opportunity for determining how to speed recovery through grazing management and other practices. To study effects of time and intensity of grazing, eight sampling areas were selected to represent particular range conditions, and a 1/10-acre enclosure was built on each. The desired grazing treatment at each area is provided by herding the sheep on specified routes as prescribed in a detailed grazing plan developed with the sheep permittee, the forest ranger, and research personnel. To provide for early grazing, sheep are permitted on the allotment on June 15 instead of July 1, and the grazing season extends until September 30.

Effects of grazing at two different intensities and at early, mid-season, and late periods are to be evaluated at two elevations.

Sheep Station Summer Range Management

U. S. Sheep Station summer range, Centennial Mountains. Continental Divide is in center background.

The U. S. Sheep Experiment Station at Dubois, Idaho, has long recognized the need for better management of its summer range located in the Centennial Mountains on the Montana-Idaho border. In the summer of 1959 we made a range survey of this area financed by the University of Idaho, and we are now developing a management plan based on results of the survey. It will provide for more efficient use of this summer range by sheep. Eventually we shall evaluate the effectiveness of this management plan and the effect of this management upon the range. Results of these studies should be applicable to similar high-elevation ranges in other parts of the West.

DESERT WINTER RANGE IMPROVEMENT

Effects of grazing treatments on survival and growth of plants in three major forage species at the Desert Experimental Range in Utah were measured from vegetation maps of plots established in 1935 and remapped in 1958. Grazing treatments over the 23-year period had been:

1. Early or midwinter grazing followed by late winter grazing at 17 sheep-days per acre.
2. Early or midwinter grazing alone at 17 sheep-days per acre.

3. Early winter grazing at 13 sheep-days per acre.
4. Early winter grazing at 10 sheep-days per acre.

Effects on Plant Survival

The following tabulation shows percentage survival in 1958 of plants that had been mapped in 1935.

Species	*Area*	*Grazing treatment*			
		1	2	3	4
Shadscale	Enclosure	24	29	17	7
	Grazed	48	31	12	34
Winterfat	Enclosure	61	63	69	76
	Grazed	46	46	50	72
Bud sagebrush	Enclosure	68	78	--	68
	Grazed	18	11	--	30

It is notable that shadscale survived better on the grazed areas than in the ungrazed enclosures. Reduction of competing species under grazing seems to have favored shadscale. This may result from the fact that shadscale is armed with spines and is only moderately utilized even under heavy grazing pressures. The combined evidence from enclosures and grazed plots indicates that shadscale is shorter lived than either bud sagebrush or winterfat.

In contrast to shadscale, winterfat and bud sagebrush, both good forage species, survived best on the ungrazed areas. Survival of these two species was better under moderate and light grazing in early winter (treatments 3 and 4) than under heavier and later grazing (treatments 1 and 2). Under early, light grazing (treatment 4) survival of winterfat was essentially equal to that on the ungrazed plots.

Effects on Plant Size

Effects of these four treatments on plant size are shown in detail in the following tabulation. Average plant size of all three species had increased during the 23-year period on both grazed and ungrazed areas, but preferred species increased most without grazing.

Species	*Grazing treatment* [1]							
	1		2		3		4	
	1935	1958	1935	1958	1935	1958	1935	1958
	Average crown area (sq. in.)							
Shadscale								
Enclosure	47	71	68	59	34	70	70	80
Grazed	37	78	32	66	50	73	47	75
Winterfat								
Enclosure	7	32	3	23	12	47	8	48
Grazed	7	15	3	9	14	32	10	36
Bud sagebrush								
Enclosed	6	31	5	35	--	45	15	36
Grazed	8	11	10	3	--	85	5	15

[1] Treatment numbers correspond to those in paragraph 1.

Shadscale plants were larger on almost all areas in 1958 than in 1935, but there was little relation to grazing treatment. For winterfat, however, the size of plants was markedly influenced by grazing treatment. In the protected enclosures winterfat plants increased in size four to eight times their initial size during the 23 years. Under moderate and light grazing (treatments 3 and 4) plants became much larger than under heavier grazing (treatments 1 and 2). Bud sagebrush increased markedly in size in the enclosures. On the grazed areas so few plants of bud sagebrush remained in 1958 and the data were so variable that little can be said about the influence of grazing treatment on plant size of this species.

WILDLIFE HABITAT MANAGEMENT

Game Forage Revegetation in Utah

The game forage restoration project in Utah, conducted cooperatively with the Utah State Department of Fish and Game, has been in progress 4 years. Work has been concentrated on restoration of deer winter range in the juniper-pinyon type, which includes nearly one-third of Utah's total range area.

Where some understory of desirable plants persists, mere elimination of the juniper-pinyon overstory by chaining, cabling, dozing, sawing, or burning after 3 years' time has increased browse and other desirable vegetation two to 30 times that on comparable uncleared areas. Where desirable forage plants are lacking in the understory, they must be planted following clearing in order to restore reasonable productivity to many juniper-pinyon areas. Also, it is frequently desirable to supplement existing understory cover with planted species to provide better soil stabilization as well as better forage. Broadcasting seed from an airplane just before chaining or cabling appears feasible from preliminary research results. Initial stands are more readily established on the light sandy soils of this vegetation type than on most other kinds of land.

Some of the most promising species for direct seeding on juniper-pinyon sites are antelope bitterbrush (*Purshia tridentata*), golden currant (*Ribes aureum*), rubber rabbitbrush (*Chrysothamnus nauseosus*), Stansbury cliffrose (*Cowania stansburiana*), fourwing saltbush (*Atriplex canescens*), tatarian honeysuckle (*Lonicera tatarica*), mountain snowberry (*Symphoricarpos oreophilus*), true mountain-mahogany (*Cercocarpus montanus*), blueberry elder (*Sambucus cerulea*), black chokecherry (*Prunus melanocarpa*), American plum (*Prunus americana*), and western virginsbower (*Clematis ligusticifolia*).

Useful broadleaf herbs include the range alfalfas such as Nomad developed in Oregon and Rambler from Canada. These appear to be more persistent in some places than the commonly used Ladak, although Ladak can be used successfully and is cheaper. Further studies are needed to show more precisely the areas where the alfalfas can be used to advantage.

Chickpea milkvetch (*Astragalus cicer*), sickle milkvetch (*A. falcatus*), arrowleaf balsamroot (*Balsamorhiza sagittata*), carrotleaf leptotaenia (*Leptotaenia multifida*), narrowleaf biscuitroot (*Lomatium simplex*), and bramble vetch (*Vicia tenuifolia*) are promising. Several lupines will be planted in the future. Of these the two most promising are silky lupine (*Lupinus sericeus*) and silvery lupine (*L. argenteus*). Some penstemons that may succeed well on difficult sites include Wasatch penstemon (*Penstemon cyanthus*), Eaton penstemon(*P. eatoni*), and Palmer penstemon (*P. palmeri*). Although not usually long lived in Utah, small burnet (*Sanquisorba minor*) performs a useful service in providing succulent green forage through the winter months and is highly palatable through the summer. It is readily established and probably will be used more widely.

Grasses that grow early in spring and that have been found well adapted and useful on spring game ranges include fairway wheatgrass (*Agropyron cristatum*), intermediate wheatgrass (*A. intermedium*), bluebunch wheatgrass (*A. spicatum*), pubescent wheatgrass (*A. trichophorum*), southern strains of smooth brome (*Bromus inermis*), Russian wildrye (*Elymus junceus*), and bulbous barley (*Hordeum bulbosum*). All of these except bluebunch wheatgrass and bulbous barley are available commercially.

In Utah deer graze these grasses in early spring while they are still young and succulent. In mixture with alfalfa, they appear to fill a definite need by satisfying the deer on foothill areas in the early spring to the extent that they reduce their depredations on lower croplands. This combination of forage plants looks especially promising in central Utah, where the problem of deer on croplands is most acute in the early springtime.

Big Game Winter Range in Northern Idaho

Maintenance of adequate winter browse range is the limiting factor in big game management in northern Idaho. Winter range problems are by no means peculiar to the West, but a special problem relative to winter range for deer and elk exists in northern Idaho. These animals largely depend upon a successional type of browse vegetation for winter sustenance. Through the course of plant succession, present wintering areas are gradually reverting from palatable brush to closed conifer stands, which are practically barren of big game forage.

Left: This closed conifer stand in northern Idaho has virtually no browse for deer and elk.

Right: Abundant growth of redstem ceanothus, mountain maple, willow, serviceberry, and other palatable browse followed removal of tree overstory.

Why the present large population of elk and deer in view of the temporary nature of their habitat?

The present game resource (an annual harvest of 7,000 elk and 10,000 deer) is a result of the numerous and extensive forest fires in the early 1900's. These fires, and especially repeated fires, created bounteous game habitat by the reversion of vegetation to extensive brush fields. Both succession of such brush fields to tree production and the great reduction in fire occurrence have resulted in continued decrease in available big game winter ranges. If our game resource is to be maintained, we must provide a stable amount of winter range.

One approach to providing adequate winter range without seriously conflicting with timber values is to adapt logging practices to temporary favoring of browse production in selected areas. Conceivably this could provide a stable amount of winter range even though such browse areas would be only temporarily located in any particular spot. In view of present and future needs for "created" winter browse areas, we have begun studies to determine the effects of various logging and slash disposal practices upon subsequent browse production.

To date, two study areas have been established--one on the Coeur d'Alene National Forest and the other on the Lolo. Each study area is receiving different treatments including varied intensities of cutting, different methods of slash disposal, and exposure where possible. All are located in the broad cedar-hemlock climax zone. Before treatment, data about herbs, shrubs, and trees by species were collected on a permanent plot basis. Observations will be continued for several years following treatment to determine which present-day logging practices best favor production of browse for big game.

RODENT-RANGE RELATIONS

Pocket Gopher Damage to Clear-cut Aspen Type

Pocket gophers, one of the most numerous range rodents on mountain watersheds, have had marked effect on a clear-cut aspen plot on the Davis County Experimental Watershed in Utah. Experimental watershed plots established in 1936 have been protected from grazing since then. In 1947, aspen was clear-cut on one-half of the aspen-covered area to determine the effect on water yield.

Until 1951 all went well. A lush cover of tall forbs and grasses developed on both aspen-cleared and uncleared areas. But between 1951 and 1957 something happened to the cleared area: grasses and several tall forbs decreased, while the annual tarweed (*Madia glomerata*) invaded the area and other annuals increased. Two perennial forbs increased: stickseed (*Lappula floribunda*), an unpalatable plant, and bluebell (*Mertensia leonardi*), which has a tough woody base. Tall forbs that decreased during this period include valerian (*Valeriana scouleri*), butterweed (*Senecio serra*), niggerhead (*Rudbeckia occidentalis*), and others. Grasses that decreased were slender wheatgrass (*Agropyron trachycaulum*), mountain brome (*Bromus carinatus*), and ryegrass (*Elymus glaucus*).

The uncut aspen area maintained an excellent understory of tall forbs and grasses, although the grasses decreased from 1951 to 1957. Part of this decrease may have been due to competition with the increasing perennial forbs and aspen.

In 1957 we examined the cutover area to determine a possible cause for these vegetative changes. We found numerous plants that had been killed that year. Cause of death of every plant examined was clearly the work of pocket gophers. In 1958 a count of gopher mounds indicated that the number of mounds on the clear-cut area (400 per acre) was about double the number found on the uncleared area (210 per acre). A count of dead plants on sample pots showed that gophers had recently killed 5 percent of the grass plants and 14 percent of the tall forbs. We found no dead grass plants on the plots in the uncleared area and only 4 percent of other tall forbs had been killed. These results suggest that further research on the problem of range rodents and possibly other factors is needed before vegetative conversion of the aspen type can be recommended for increasing water yield in this area.

WATERSHED MANAGEMENT RESEARCH

Soil stability and flood control go hand-in-hand. Wherever soil stability is impaired and flood control lessened, both hydrologic and productive functions of a watershed are jeopardized. This was forcefully reemphasized last summer when three floods damaged the city of Boise, Idaho, by floods from several small canyons near Logan, Utah, and by a flood at Salt Lake City.

The main effort of this division continues to be directed toward (1) learning how to maintain soil stability and thus preserve hydrologic control in the face of demands for increased use of mountainous watersheds, and (2) seeking ways of restoring hydrologic control on damaged or abused watersheds so as to speed their return to maximum production. While working toward these objectives, we constantly realize the need to avoid undue reduction of water yields critically needed in our semiarid valleys.

Our research approach to field studies includes experiments on small plots where we can control a number of variables. We then extend these experiments (utilizing knowledge gained under controlled conditions) to small complete watersheds where results from a more complex area can be measured in terms of streamflow, sedimentation, and production of timber or forage.

Some of the major accomplishments of this division during 1959 are reported here under the broad research objectives of maintenance and restoration of acceptable watershed conditions.

MAINTENANCE OF RANGE WATERSHEDS

Earlier studies of soil stability in southern Idaho and northern Utah have shown that on highly porous sandy soils derived from granite, gneiss, and schist rocks, a rather uniform proportion of the ground surface--65 to 70 percent--must be covered with plants and litter to prevent overland flow from summer storms and soil erosion. Recently these studies were extended to finer textured soils of greater densities to learn whether the same general cover requirement persists. The cover requirements were substantiated, and tests at two locations also revealed that soil compaction strongly influences erosion losses, somewhat independently of plant and litter cover.

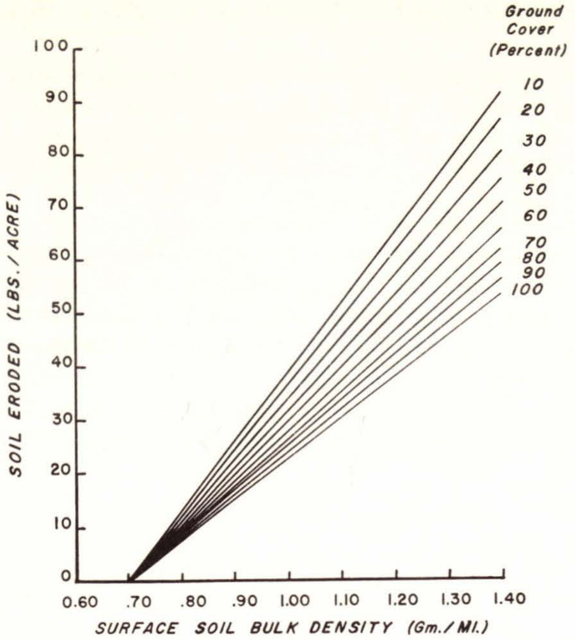
Medium-Textured Soils in Southern Montana

On elk winter range sites in southern Montana characterized by medium-textured soil derived from a mixture of sandstone and shale, trampling and pawing by game animals deteriorated the ground cover and compacted the soil. For two seasons we collected and measured eroded soil from numerous small catchment plots. The amount of eroded soil was related to ground cover and soil bulk density. Bulk density is used as an index of soil compaction.

Two natural storms of short duration not exceeding 1.5 inches per hour in maximum intensity, eroded the least amount of soil--the equivalent of 21 pounds per acre per storm--from sites supporting a ground cover of 100 percent in combination with a soil bulk density of 0.70. Almost as little soil was eroded where the ground cover was only 70 percent, but as the amount of ground cover decreased below 70 percent, soil losses accelerated rapidly. A ground cover of at least 70 percent, therefore, appears to be one requirement for controlling erosion on these range sites.

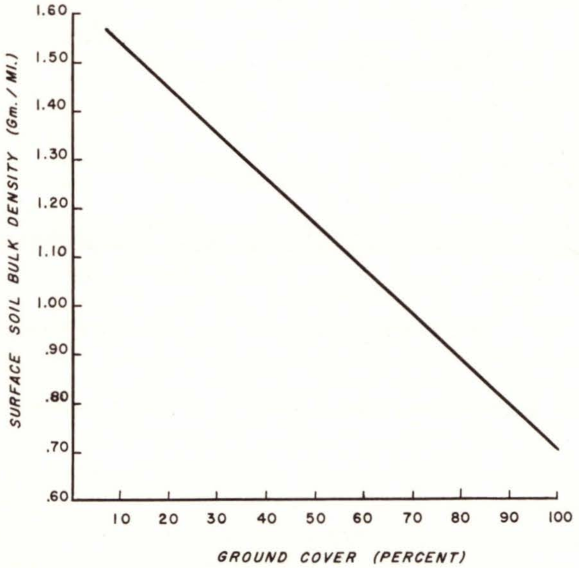
When soil bulk densities exceeded 0.70, soil erosion increased; these increases were lowest on sites having complete or nearly complete ground cover, but became greater as ground cover decreased. There appears to be no range of bulk density values corresponding to that range of 70 to 100 percent of ground cover that provides essentially equal control of soil erosion.

Of the range sites studied, those having ground cover densities of less than 70 percent were usually associated with soil bulk densities substantially greater than 1.00. Conversely, ground cover densities of



Relation of soil erosion, caused by summer storms on the Gallatin elk winter range, to bulk density of the surface 2 inches of soil.

70 percent or more were associated with soil bulk densities of 1.00 or less. These relations are ascribed partly to the effects of grazing and trampling which combined to reduce plant cover density and at the same time increase soil compaction. For the present, it appears that effective erosion control on game range sites is provided by a minimum ground cover density of 70 percent in combination with soil bulk densities of 1.00 or less. A reevaluation will be made as more soil loss measurements accrue from storms of longer duration and greater intensity.

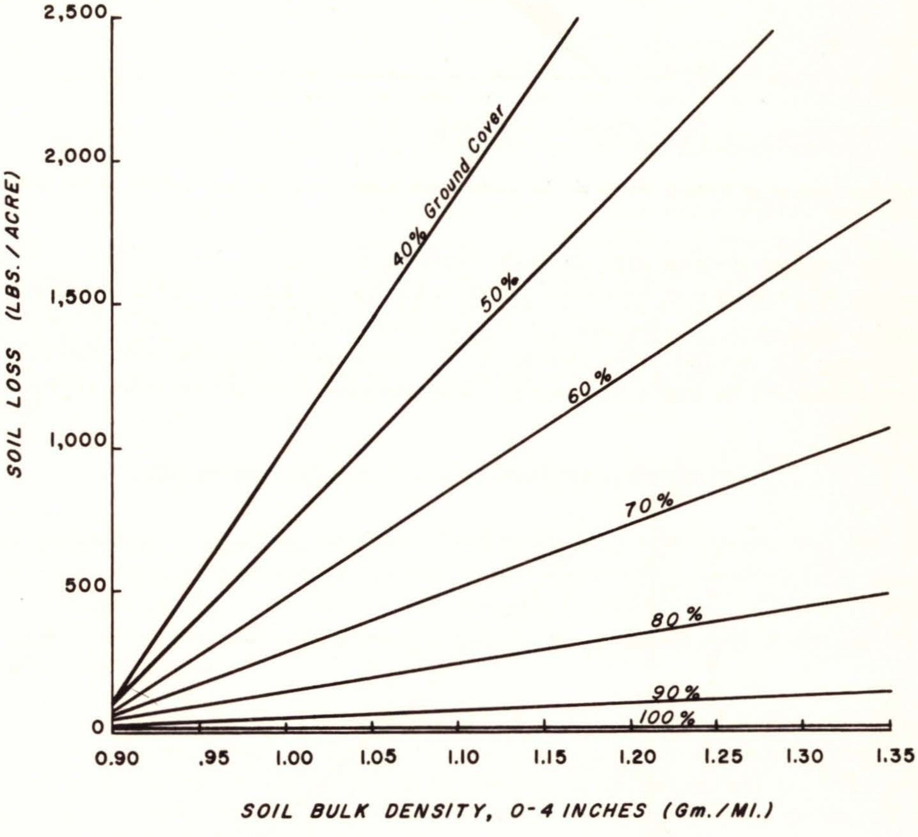


Relation of ground cover density to soil bulk density on the Gallatin elk winter range.

Heavy-Textured Soils in Central Utah

Last summer we installed a series of infiltrometer plots on a heavy-textured limestone soil common to subalpine rangeland in central Utah. To approximate severe natural storm intensities and durations, our technicians prewet the plots and then applied a simulated rainstorm at a rate of 3 inches in 50 minutes, using an infiltrometer. Here, the object was to determine the amount of overland flow and soil loss associated with a storm of typical flood-producing intensity.

Data collected from these plots are now being analyzed. Results already available suggest relations similar to those found in southern Montana. Soil bulk density at this location markedly influenced overland flow and soil loss. The percentage of applied rainfall that became overland flow varied primarily with the bulk density of the soil and secondarily with the percentage of the ground surface cover. Even with 100 percent ground cover, runoff is high from heavy clay sites having high bulk densities but, conversely, overland flow does not reach anticipated proportions on sites having low bulk densities (indicative of high soil porosity) even when the ground cover is less than 50 percent complete.



Relation of soil eroded to bulk density of the surface 4 inches of soil under the influence of different ground cover densities on a subalpine range in Utah.

On the other hand, ground cover density in combination with soil bulk density materially influences soil erosion. Where ground cover is dense, erosion remains low, but when ground cover decreases and bulk density increases, erosion increases greatly. The favorable effects of low soil bulk density and adequate ground cover suggest strongly that these high-elevation ranges should be grazed moderately and during periods of low surface soil moisture when compaction by trampling is likely to be least.

MAINTENANCE OF TIMBERED WATERSHEDS

Logging Disturbance--Small Watershed Evaluation Studies in Southern Idaho

A critical problem on operated timberlands in our station's territory is that of keeping sedimentation in stream channels to a minimum. Exploratory investigations, results of which were published last year, emphasize the fact that many logging roads and other types of logging disturbance contribute damaging sediment. Alarmed over this threat to vital water supplies, forest managers as well as logging operators, realize the need for finding some practical solution to this problem.

To this end, Intermountain Station in cooperation with Region 4 is now developing plans for a pilot watershed approach to the problem of logging steep easily disturbed slopes commensurate with watershed protection requirements. For this study, a watershed supporting a mixed stand of oldgrowth ponderosa pine and Douglas-fir was selected on the Payette National Forest. The study has been divided into five segments:

1. Installation of climatic and streamflow recording instruments and calibration of the watershed area.

2. Survey of plant cover and soil conditions prior to logging.

3. Adapting those techniques and equipment believed best for logging on highly variable terrain and unstable soils.

4. Repairing unavoidable logging damage to the watersheds by using the most effective methods for stabilizing roads, landings, and skidways.

5. Observing and recording the effects of treatment for several years on surface soil movement, channel sedimentation, and streamflow regime.

Jointly we achieved progress in 1959 toward completing the first two phases of this program. Recording and storage precipitation gages were set out on the area, a stream-gaging station was installed by Region 4, and devices for measuring instantaneous peak flows were installed on four main channels. A detailed soil survey described eleven soil units that were differentiated chiefly by depth to bedrock, and to a lesser extent by stone content and by color. All soils were found to be loose-grained and practically structureless. Depths to bedrock range from less than 6 inches on slopes greater than 60 percent to more than 72 inches on well drained benchlands. This study will continue for several years.

RESTORATION OF DAMAGED WATERSHEDS

East Sierra Nevada Watersheds Gaged

Along the east slope of the Sierras occasional extra-heavy winter rains on shallow to medium-depth snowpacks produce damaging floods. Devastation from these recurrent floods in the Truckee River basin led to the development of a research program to pinpoint the causes and determine the possibilities of prescribing preventive measures.

The active program now under way followed selection of four small pilot watersheds for research purposes. These watersheds are timbered and represent three prominent vegetation condition classes: oldgrowth, cut-over, and burned. Pure stands of Jeffrey-ponderosa pine dominate the lower reaches, while mixed stands of pine and white and red fir prevail near the crest of the upper ridges. Low-growing shrubs occupy openings enlarged by logging and wildfire.

We believe that these combinations of types within the pilot watersheds are representative of the entire flood-source area in which the broad types, pine and pine-fir, occupy 46 percent of the land. Another 22 percent of the area supports a variety of shrub species in openings adjacent to timber, and much of the remaining area is bare or sparsely vegetated.

The experimental watersheds range in size from 180 to 3,800 acres. Two small ones are now in operation; the other two are scheduled for operation soon. Streamflow is measured by 120° V-notch weirs designed to handle the maximum surge of flood water that may arise from these areas.

Construction crew pours a splash apron below a 120° V-notch weir structure. This weir is designed to handle rain-on-snow flood waters to be expected from a small watershed in the Bald Mountains on the eastern slope of the Sierra Nevada.

After these watersheds are calibrated, a series of treatments will be applied to determine their effect on (a) the delivery of overland and subsurface flow of water to a stream channel and (b) surface runoff once it becomes channel flow. The first major effort will hinge on manipulation of tree cover, including brush conversion and planting, and construction of seepage pits and trenches on sloping land.

Secondary measures planned entail the use of minor engineering works, such as small detention earth dams and water-spreading canals. All treatments will be integrated so as to lessen flood volumes, reduce and delay peak flows, and at the same time avoid undue reduction of total water yields.

Evaluation of Summer Flood Control in Northern Utah

Parrish Creek watershed in northern Utah produced violent floods in the summer of 1930. In the early days following settlement in the valley, the watershed was abusively overgrazed and burned; this resulted in varying degrees of destruction of protective plant cover. Erosion on the slopes reached spectacular proportions and produced several disastrous mud-rock floods from the main channel. Numerous buildings were destroyed, and many acres of valuable land were buried under sediment as deep as 12 feet in the valley below the mouth of the canyon.

In 1934 an extensive rehabilitation program was started on this watershed. What was once an active flood plain is now rapidly becoming a suburban residential area.

To detect changes in the streamflow of Parrish Creek as a result of the rehabilitation treatment, Centerville Creek, located to the south, was used as the experimental control. This drainage basin has always been used conservatively and the natural hydrologic functioning of this watershed has never been impaired. It has never flooded.

Time-trend analyses were made to determine the duration and magnitude of changes in streamflow from the Parrish watershed during the past 22 years. Correlation analyses of precipitation on the watershed and annual streamflow from Centerville Creek indicate that these two factors are highly correlated and that for the period no significant differences in the annual discharge have occurred other than those resulting from annual variation in precipitation.

When the flow of Centerville Creek is used as a basis for comparison, annual discharge from Parrish Creek appears to have declined. During 22 years of record, the decrease of actual yield from the expected flow amounts to 2.70 area inches, or an average loss of 0.123 inch. Of the total reduction in streamflow, 83 percent occurred during the first 11 years following rehabilitation and only an insignificant amount in the last 11 years. Water yield during the period of seasonal low flows has not been affected appreciably. Most of the reduction in streamflow is limited to the spring snowmelt period when peak discharges are high and the supply of water usually exceeds demands.

Peak discharge dates have been delayed several days into the spring, and the volume of June discharge appears to be increasing. When viewed from the standpoint of regained soil stability, effective flood prevention, and improvement in regularity and quality of flow, this small reduction in annual water yield is a very modest cost for watershed protection.

PUBLICATIONS

BAILEY, REED W. The challenge to watershed management. Forestry Centennial Conf. Proc., Oregon State College, Corvallis, Ore., pp. 59-62.

Urges a geared-up program to implement the watershed management job in general and the watershed research job specifically.

BARROWS, J. S. Center probes fire secrets. West. Conserv. Jour. 16(1): 68-69, illus.

Describes the Northern Forest Fire Laboratory being erected at Missoula and summarizes the role of the laboratory in meeting critical nationwide fire problems and those of the Intermountain West and Alaska.

BARROWS, J. S. Fire fighting in laboratories. West. Forestry and Conserv. Assoc., West. Forest Fire Res. Coun. Proc., pp. 2-4.

Discusses the research program and scientific facilities at the Northern Forest Fire Laboratory in relation to needs of resource managers.

BARROWS, J. S. The northern forest fire laboratory. The Timberman 60(7): 40-41. (No reprints available.)

Describes the facilities and physical plant of the Northern Forest Fire Laboratory and explains how the work of this laboratory fits into the nationwide fire research program.

BOYD, R. J. Cleaning to favor western white pine--its effects upon composition, growth, and potential values. Jour. Forestry 57: 333-336.

Results of cleanings in 1935 in young mixed softwood stands on two national forests in the Inland Empire indicate that this silvicultural measure is a sound investment.

BOYD, RAYMOND J., Jr. Silvics of western redcedar. Misc. Pub. 20, 17 pp., illus. (Processed.)

Describes habitat conditions, life history, and races and hybrids based on selected references and unpublished data through 1957.

CRADDOCK, GEORGE W. Watershed management problems of the Intermountain West. Soc. Amer. Foresters Proc. 1958, pp. 31-32.

Reviews the numerous and varied watershed management problems facing land managers in the Intermountain West. They fall into three broad categories: watershed restoration, prevention of watershed deterioration, and improvement of water yield.

DENTON, ROBERT E., and CHARLES D. LEAPHART. Symptoms of abnormal crown deterioration in western white pine stands. Research Note 69, 4 pp., illus. (Processed.)

Describes detailed symptoms of a basal and internal killing of western white pine tree crowns from an undetermined cause. An aphid and some needle-cast fungi were found associated with the damage, but their significance has not been determined.

DIVISION OF FOREST FIRE RESEARCH. Totalizing wind counter for contacting type anemometers. Fire Control Notes 20(1): 7-10, illus. (Also published as Tech. Equip. Rpt. No. F-2, U.S. Forest Service, May 5, 1958.) (No reprints available.)

Describes a low voltage totalizing counter that keeps battery drain to a minimum if becalmed on contact, and eliminates spurious count due to contact chatter.

DIVISION OF FOREST FIRE RESEARCH. Battery-operated fan psychrometer. Fire Control Notes 20(1): 20-22. (Also published as Electric Fan Psychrometer in Tech. Equip. Rpt. No. F-1, Forest Service, May 5, 1958.) (No reprints available.)

Describes a small 6-volt electric motor and fan unit for aspirating the thermometer tubes of a psychrometer.

DIVISION OF FOREST FIRE RESEARCH. Aluminum rain gage and plastic measuring stick for fire-weather stations. Fire Control Notes 20(4): 111, illus. (No reprints available.)

Describes standard Forest Service specifications for a 1/2-inch capacity, seamless aluminum rain gage that replaces the older soldered galvanized iron type. Gives specifications for a plastic measuring stick to replace the wooden type.

DIVISION OF FOREST FIRE RESEARCH. Belt weather kit. Fire Control Notes 20(4): 122-123, illus. (No reprints available.)

Describes a belt-attached fitted canvas container that holds a psychrometer, water bottle, hand wind gage, notebook, pencils, writing board, and space for tables, small compass, etc. Designed primarily for fire control purposes, but used on such projects as aerial spraying.

DIVISION OF FOREST FIRE RESEARCH. Aluminum knockdown weather instrument shelter. Fire Control Notes 20(4): 139-140. (No reprints available.)

Describes a 35-pound portable shelter made of sheet aluminum panels. Stand consists of aluminum tubing and bar crossbracing that folds as a single unit.

DIVISION OF FOREST INSECT RESEARCH. Forest insect conditions in the Intermountain and Northern Rocky Mountain States during 1958. Misc. Pub. 18, 13 pp., illus. (Processed.)

Reviews the status of numerous forest insect pests during 1958, including major species as well as those of lesser economic importance.

ELLISON, LINCOLN. Role of plant succession in range improvement. Amer. Assoc. Adv. Sci. 1956. Symposium on Grasslands, Pub. 53, pp. 307-321.

Discusses effects of grazing on range plants and different vegetation types. Gives examples of range improvement under grazing use. Suggests that a level of range productivity much closer to the pristine than has generally been supposed possible can be maintained.

FOILES, MARVIN W. Silvics of grand fir. Misc. Pub. 21, 15 pp., illus. (Processed.)

Describes habitat conditions, life history, and racial variations based on selected references and unpublished data through 1958.

FRISCHKNECHT, NEIL C. Effects of presowing vernalization on survival and development of several grasses. Jour. Range Mangt. 12: 280-286, illus.

Reports results of vernalizing seed of grasses by storage in a snowbank or cold locker. For some species cold treatments hastened emergence from spring planting, aided survival on dry sites, and resulted in seed production from spring plantings a year earlier than usual.

FUQUAY, D. M. Lightning fire research. West. Forestry and Conserv. Assoc., West. Forest Fire Res. Coun. Proc. 1958, pp. 7-9.

Describes some early experiments with static electricity and development of the lightning rod. Briefly reviews the lightning research activities of four western research groups, including the 1957 and 1958 Project Skyfire programs.

FURNISS, MALCOLM M. Reducing Douglas-fir beetle damage--how it can be done. Research Note 70, 6 pp., illus. (Processed.)

Discusses methods of locating infested trees, salvage, logging, possible use of insecticides, and effects of silvicultural treatment in reducing Douglas-fir beetle damage.

GRAHAM, DONALD P. Dwarfmistletoe survey in Kootenai National Forest. Research Note 67, 5 pp., illus. (Processed.)

Roadside surveys showed heavy infection of larch stands in most districts on the Kootenai Forest. Dwarfmistletoe in young stands was 5.8 times heavier with an overstory than without one. Lodgepole pine stands were infected throughout the forest.

GRAHAM, DONALD P. Dwarfmistletoe survey in Coeur d'Alene National Forest. Research Note 68, 5 pp., illus. (Processed.)

Larch dwarfmistletoe was found in 64 percent of the stands traversed in roadside surveys. Young stands with an overstory were 5.5 times as heavily infested as young stands without an overstory. Infected Douglas-fir stands were common, and several infected lodegpole pine stands were encountered.

GRAHAM, DONALD P. A new host for the larch dwarfmistletoe. Plant Disease Rptr. 43(5): 594. (Processed.) (No reprints available.)

Vigor and development of larch dwarfmistletoe and the formation of witches'-brooms on planted jack pines (*Pinus banksiana*) are characteristic of the parasite on its usual host tree.

GRAHAM, DONALD P. Pole blight threatens western white pine. West. Conserv. Jour. 16(1): 16, 60, 70, illus.

Briefly summarizes the history of this disease in the Inland Empire, and describes its nature and the extent of its damage to white pine. Reports impact of the disease on the white pine industry, and discusses possible causes of the disease.

HARDY, C. E. Weather measurements for fire behavior. West. Forestry and Conserv. Assoc., West. Forest Fire Res. Coun. Proc. 1958, pp. 13-14.

Reviews some factors that influence fire behavior, especially weather factors. Mentions sources of fire weather information, and describes new and modernized instruments for measuring fire weather factors.

HAUPT, HAROLD F. A method for controlling sediment from logging roads. Misc. Pub. 22, 23 pp., illus. (Processed.)

Several road and slope characteristics were incorporated into an equation that can be used to determine the width of buffer strips necessary to protect lower roads or stream channels from sediment damage emanating from road construction activities.

HAUPT, HAROLD F. Road and slope characteristics affecting sediment movement from logging roads. Jour. Forestry 57: 329-332, illus.

Four road and slope characteristics--the slope obstruction index, cross ditch interval squared, embankment slope length, and the product of the cross ditch interval and road gradient--were found to influence sediment movement from logging roads.

HERRINGTON, ROSCOE B. Resource base for expanded markets in the Mountain States. Mont. State Univ., School of Forestry Bul. 9, 36 pp., illus.

Surveys the long-range growth opportunities provided by Mountain States natural resources and appraises the impact that resource development could have on future timber resource development within the region.

HOLMGREN, RALPH C., and JOSEPH V. BASILE. Improving southern Idaho deer winter ranges by artificial revegetation. Idaho Fish & Game Dept. Wildlife Bul. 3, 61 pp., illus.

A handbook of recommendations for revegetating big-game ranges, particularly with bitterbrush (***Purshia tridentata***); offers recommendations on collecting, cleaning, and treating seed; on season, depth, and methods of seeding; and on protection and management of the plantation.

HUTCHINGS, S. S., and RALPH C. HOLMGREN. Interpretation of loop-frequency data as a measure of plant cover. Ecology 40: 668-677, illus.

Discusses theoretical relation of "loop-density" indices to plant cover. The inherent positive bias of loop-frequency data depends on plot (loop) size and on the number and size of plants. Gives algebraic equations by which loop-density indices can be corrected to percent plant area.

HUTCHINGS, S. S., and M. J. MORRIS. Use of distance measurements for determining plant density in semi-desert vegetation. Ninth Internatl. Bot. Cong. Proc. II: 174 (Abstract)

Discusses the relation of distance measurements to spatial distribution of plants. Nearest neighbor, closest individual, and point-centered quarter methods for measuring plant density and spatial distribution were tested on stands of small desert shrub vegetation and compared with plant counts.

HUTCHISON, S. BLAIR. Production-distribution trends and freight rates as they affect Mountain States lumber producers. Research Paper 59, 14 pp., illus. (Processed.)

An analysis of long-range national trends in lumber distribution, plus a general consideration of probable effect of freight rates on the lumber distribution pattern of the Mountain States.

JOHNSON, PHILIP C. Forest insect research in the years ahead. Forestry Centennial Conf. Proc., Oregon State College, Corvallis, Ore., pp. 19-33. (No reprints available.)

Future research in forest entomology will stress need for more precise knowledge of insect biology based on fundamental investigations by scientific teams composed of technicians in several related biological and physical disciplines.

JULANDER, ODELL, JESSOP B. LOW, and OWEN W. MORRIS. Influence of pocket gophers on range grass plantings. Jour. Range Mangt. 12(5): 219-224, illus.

JULANDER, ODELL, and NICK CHOURNOS. Utah experiments reveal pocket gophers play ruinous role in range reseeding. The Natl. Wool Grower 49(7): 17, illus.

Both articles discuss effects of pocket gophers on seeded mountain range. Gophers were very destructive to the seeded area studied. Density of gophers, character of soil, and seed species used were important factors.

KIMMEY, JAMES W. Forest diseases in multiple-use management in the western United States. Soc. Amer. Foresters Proc. 1958, pp. 74-77.

Tree diseases may affect any forest use and the effect may be different for each type of use; conversely, each forest use may affect tree diseases. Examples of the interrelations of forest diseases and management for the various uses are given and discussed.

KIMMEY, JAMES W., and JAMES L. MIELKE. Western dwarfmistletoe on ponderosa pine. U. S. Dept. Agr., Forest Service, Forest Pest Leaflet 40, 7 pp., illus.

This leaflet briefly describes the parasite and the damage it causes to ponderosa pine, and discusses control procedures.

KOTOK, E. S. Putting the handicapped species to work. Soc. Amer. Foresters Proc. 1958, pp. 25-27.

Increasing market acceptance and demand for the less-used species of timber in the Rockies proves that their utility is good.

LEAPHART, CHARLES D. Drought damage to western white pine and associated tree species. Plant Disease Rptr. 43(7): 809-813, illus. (Processed.)

An unusually dry summer in 1958, characterized by abnormally high temperatures, damaged western white pine, western larch, grand fir, and lodgepole pine in an area in northeastern Washington and northern Idaho. Damage ranged from foliage wilting to death of trees, and affected trees from 3 to 25 feet tall.

LEAPHART, CHARLES D. This mistletoe gives kiss of death to trees. West. Conserv. Jour. 16(1): 44-47, illus.

Estimated annual loss of 863 million board feet in western conifers caused by the dwarfmistletoes represents nearly 4 percent of the total annual sawtimber cut in the West. The article describes types of damage and losses and discusses control measures.

LEAPHART, CHARLES D. Dwarfmistletoe surveys and research to date. 49th West. Forestry Conf. Proc., 1958, pp. 35-36.

Describes the impact on western forests caused by the dwarfmistletoes, and reports what has been learned about their distribution and control through surveys and research. Discusses continuing problems that require further research.

LEAPHART, CHARLES D., and LAKE S. GILL. Effects of inoculation with *Leptographium* spp. on western white pine. Phytopathology 49: 350-353, illus.

Using seven isolates of *Leptographium*, various techniques and several types of inoculum, 2,300 inoculations on roots and stems of 321 trees, during a 3-year period resulted in the following conclusions: The fungus contributes to deterioration of root systems of pole blight-affected trees inversely proportionate to the tree's ability to callus diseased tissue; and virulence of the form of *Leptographium* in a tree may be associated with both the lesion development pattern on the tree and that tree's rate of decline.

LLOYD, MERLE G. Air currents send spores over ridge. West. Conserv. Jour. 16(1): 32-33, illus.

Particles of silver iodide from a ground generator at a spore source believed to be harmlessly located over a ridgetop from a western white pine plantation, were recovered later in the plantation. This experiment solved the riddle of the source of blister rust infection in the planted pines.

LLOYD, MERLE G., CLYDE A. O'DELL, and J. H. WELLS. A study of spore dispersion by use of silver-iodide particles. Amer. Met. Soc. Bul. 40(6): 305-309, illus.

Silver-iodide particles were used to simulate movement of white pine blister rust spores. Particles released at a suspected source of infection were traced into the western white pine plantation where unexplained infection had occurred.

LOWERY, DAVID P. Effect of moisture content on the power required to saw logs. Research Note 62, 4 pp. (Processed.)

Power measurements, both ampere- and watt-hour, indicate that moisture content of logs markedly affects power consumption required for sawing. The higher the moisture content, the less power is required in sawing.

LOWERY, DAVID P. Management of log inventories. Research Note 63, 4 pp., illus. (Processed.)

Logs stored out of water deteriorate from stain, decay, and end checking. Two sprinkling systems are compared and evaluated.

LOWERY, DAVID P. Techniques for evaluating log deck conditions. Research Note 64, 5 pp., illus. (Processed.)

Techniques for measuring temperature, relative humidity, pH of the moisture in the wood, circulation of air within the deck, depth of end checking, and location and species of fungus attack within log decks are discussed.

LYNCH, DONALD W. Effects of a wildfire on mortality and growth of young ponderosa pine trees. Research Note 66, 8 pp., illus. (Processed)

Describes the effects of a wildfire on the different sizes of trees on a 35-year-old ponderosa pine stand in northeastern Washington.

MARSTON, RICHARD B. Use of a nuclear soil moisture meter in studies of evapotranspiration on mountain soils. Soc. Amer. Foresters Proc. 1958, pp. 39-41, illus.

Describes an exploratory test with a neutron soil moisture probe. Although a significant relationship exists between moisture determinations by the neutron probe and by paired gravimetric samples, replicate determinations exhibited wide variation.

MIELKE, JAMES L. Infection experiments with *Septogloeum gillii*, a fungus parasitic on dwarfmistletoe. Jour. Forestry 57: 925-26.

Dwarfmistletoe on lodgepole pine was successfully inoculated with this parasitic fungus on four test plots on the Cache and Targhee National Forests in 1952. The fungus gradually died out and by 1956 could not be found on the test plots. Since the fungus could not maintain itself in these areas, its utility in biological control here seems doubtful.

MILLER, DOUGLAS R., JAMES W. KIMMEY, and MARVIN E. FOWLER. White pine blister rust. U. S. Dept. Agr., Forest Service, Forest Pest Leaflet 36, 8 pp., illus.

This leaflet describes this virulent disease of 5-needled white pines, its spread in the United States since its introduction about 1900, and tells how (through interruption of its life cycle) the disease is being controlled where white pines are under intensive management.

MILLER, ROBERT L., and ALVIN K. WILSON. Lumber production in Wyoming, 1957. Rocky Mountain Forest & Range Expt. Station, Forest Survey Release 2, 9 pp., illus.

Sawmills in Wyoming produced 108,691,000 board feet of lumber in 1957, according to an official survey. This report analyzes production by timber species, geographic location, and sizes of sawmills.

PACKER, PAUL E. Watershed management problems in the Rocky Mountain Region. Research Paper 57, 31 pp., illus. (Processed.)

Lists and describes the watershed management problems and areas in the Northern Rocky Mountain Region where they need most attention. Discusses three problems deserving immediate research.

PARKER, D. E. The forest pest situation in the Intermountain area. Soc. Amer. Foresters Proc. 1958, pp. 60-62.

Summarizes information on forest insect and forest disease conditions in the Intermountain area during 1958 as determined by annual cooperative surveys.

PLUMMER, A. PERRY. Restoration of juniper-pinyon ranges in Utah. Soc. Amer. Foresters Proc. 1958, pp. 207-211, illus.

Discusses the extent, history, and values of the juniper-pinyon ranges of Utah. Reports preliminary results of big-game forage restoration program in this type being conducted by the Utah State Department of Fish and Game and Intermountain Station. Game forage, natural or seeded, can be increased greatly by eradicating closed stands of juniper-pinyon.

ROE, ARTHUR L., and CORLAND L. JAMES. Management problems in the Engelmann spruce-subalpine fir forest. Soc. Amer. Foresters Proc. 1958, pp. 68-71.

Reviews possibilities for managing Engelmann spruce-subalpine fir forest, including the utilization and marketing of spruce and the silvicultural potential of the type. Discusses five major problems in management.

SCHAEFER, VINCENT J. Use of the 60-second-print camera for stereophotography of project fires and related activities. Fire Control Notes 20(3): 89-90. (No reprints available.)

The polaroid process in photography is becoming more useful in all phases of forestry. Describes techniques for using the polaroid camera in research and analysis of forest fires; shows advantages of using a stereo approach to analysis of fire situations.

SCHAEFER, VINCENT J., and JOHN H. DIETERICH. The seeding of cumulus clouds by ground based silver iodide generators. Jour. Appli. Math. and Phys. (ZAMP) 10(2): 174-188, illus. (No reprints available.)

Summarizes thunderstorm and lightning research in the northern Rockies prior to the 1957 field season. Describes field operations during the 1957 season and shows effects of seeding in cumulus clouds.

SMITH, JUSTIN G. Additional modifications of the point frame. Jour. Range Mangt. 12: 204-205, illus.

Details are given for improvement of the point frame equipment for use in sampling vegetation under southern Idaho conditions.

STAGE, ALBERT R. A cruising computer for variable plots, tree heights, and slope correction. Jour. Forestry 57: 835-836, illus.

Explains fully the means by which marginal trees in variable plot cruising, tree heights, and horizontal distances can be conveniently determined.

STAGE, ALBERT R. Site index curves for grand fir in the Inland Empire. Research Note 71, 4 pp., illus. (Processed.)

Provides a means for determining site index for grand fir whether or not the number of rings in 1.5-inch radius from pith at breast height is known.

TACKLE, DAVID. A further test of tree bands for cone protection. Jour. Forestry 57: 373.

Fourteen-inch-wide, smooth aluminum bands are the minimum size that can be used safely for preventing red squirrels from climbing trees and cutting cones and cone-bearing branches.

TACKLE, DAVID. Progress in management of Rocky Mountain lodgepole pine. Soc. Amer. Foresters Proc. 1958, pp. 66-68, illus.

Reviews recent trends in management of lodgepole pine in the Rocky Mountain region. Discusses advances made in obtaining resource information, forestry attitudes toward management problems and practices, and trends in utilization and marketing.

TACKLE, DAVID. Silvics of lodgepole pine. Misc. Pub. 19, 27 pp., illus. (Processed.)

Describes habitat conditions, life history, races, hybrids, and reaction to competition based on selected references and unpublished data through 1957.

TERRELL, TOM T. Budworm down, other insects up. West. Conserv. Jour. 16(1): 52-53, 69, illus. (No reprints available.)

Summarizes forest insect conditions in the northern Rocky Mountain region in 1958. Most injurious forest insect pests, except spruce budworm, were at a low level.

TERRELL, TOM T. Sampling populations of overwintering spruce budworm in the northern Rocky Mountain region. Research Note 61, 8 pp., illus. (Processed.)

Spruce budworm populations are sampled by forcing overwintering larvae to break hibernation. The study includes variation of larval population due to exposure, limbs compared to tree bole, and relationship between defoliation and subsequent larval population.

THOMPSON, ROBERT, and RICHARD O. MEEUWIG. Progress report: 1958 phase of Pleasant Creek watershed restoration evaluation study. 19 pp., illus. (Processed.) (Restricted distribution.)

This study covers the first 3-year evaluation period following treatments on the Pleasant Creek watershed, much of which has undergone pronounced alteration of cover.

TUNNOCK, ARCHIBALD, Jr., and J. A. RUDINSKY. Observations on the life-cycle of the balsam woolly aphid, *Adelges picea* (Ratz.) in the Willamette Valley of Oregon. Canad. Ent. XCI: 208-212, illus.

Describes the method of following four successive generations of the balsam woolly aphid. The insect's development was correlated with temperature and precipitation near the grand fir host trees.

*WATERS, CHARLES W. Some studies on Elytroderma blight of ponderosa pine. II. Montana Acad. Sci. Proc. 18: 7-8. (Abstract)

Reports studies establishing the systemic nature of this disease. Infection moves distally from current year's needles and shoots to the new terminal bud and into developing dwarf shoots and needle fascicles. The following year it spreads to the surface of the new needles and sporulates.

WILSON, ALVIN K. Montana Christmas tree exports continue decline. Research Note 65, 4 pp., illus. (Processed.)

The decline in Montana Christmas tree exports that began in 1957 continued through 1958, but nearly 3.6 million trees were shipped from the State in 1958. Disease and insect attacks were contributing factors, but the rate of decline appears to be leveling off.

WILSON, ALVIN K. Pole production in northern Rocky Mountains slumps in 1958. Research Note 72, 4 pp. (Processed.)

The decline of commercial pole production in northern Rocky Mountain states to 340,231 poles in 1958 from the 518,893 poles produced in 1957 is recognized as one facet of the general 1957-58 recession. Buyers purchased on a current requirements basis, and curtailed logging operations in western redcedar source areas reduced the amount of available and operable redcedar pole stumpage.

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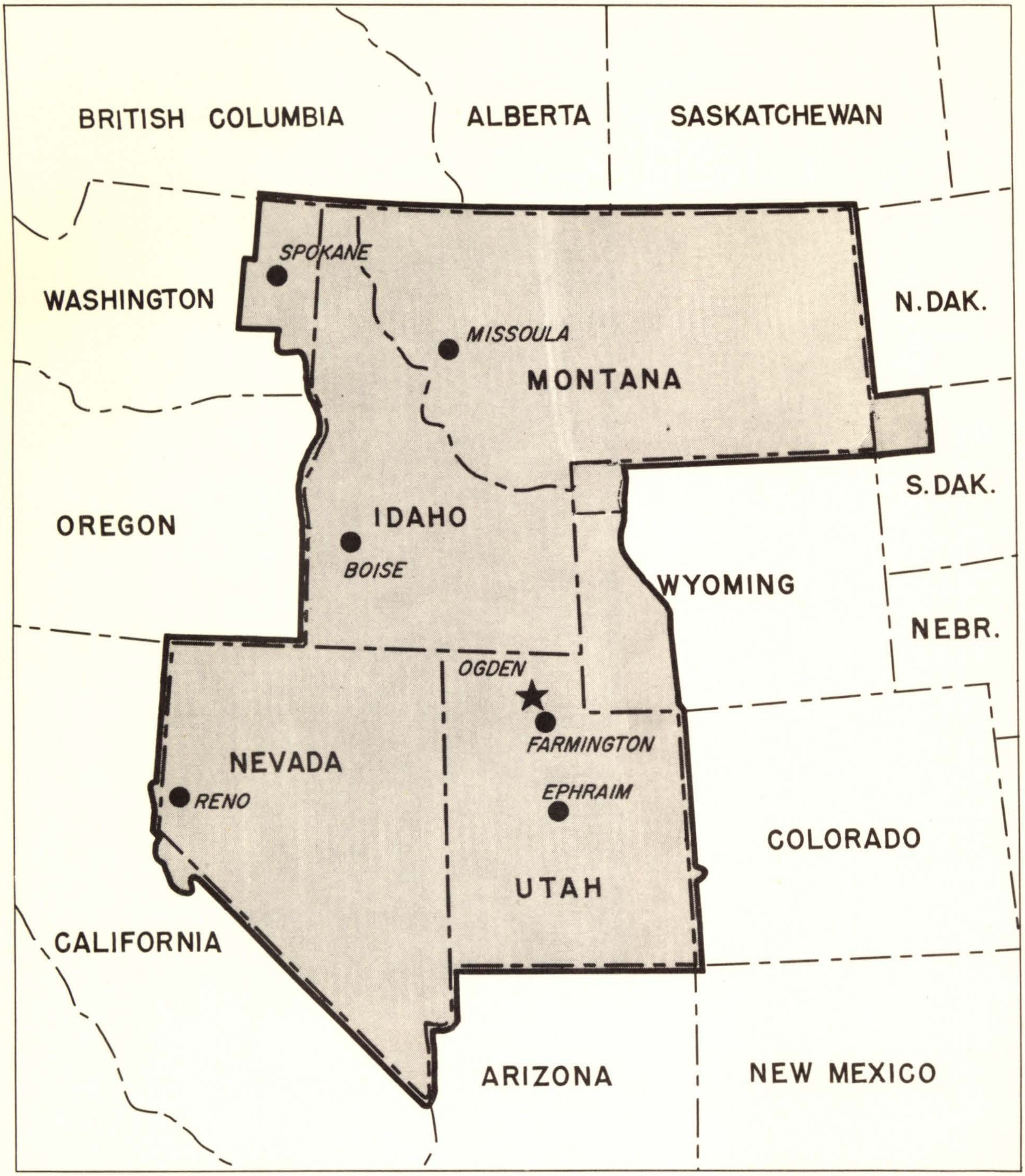
* Cooperator


BRITISH COLUMBIA
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